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Rosseland
Centre
for Solar
Physics

Annual report
2022

Norwegian
Centre of
Excellence

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Annual report 2022

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Rosseland Centre for Solar Physics (RoCS)

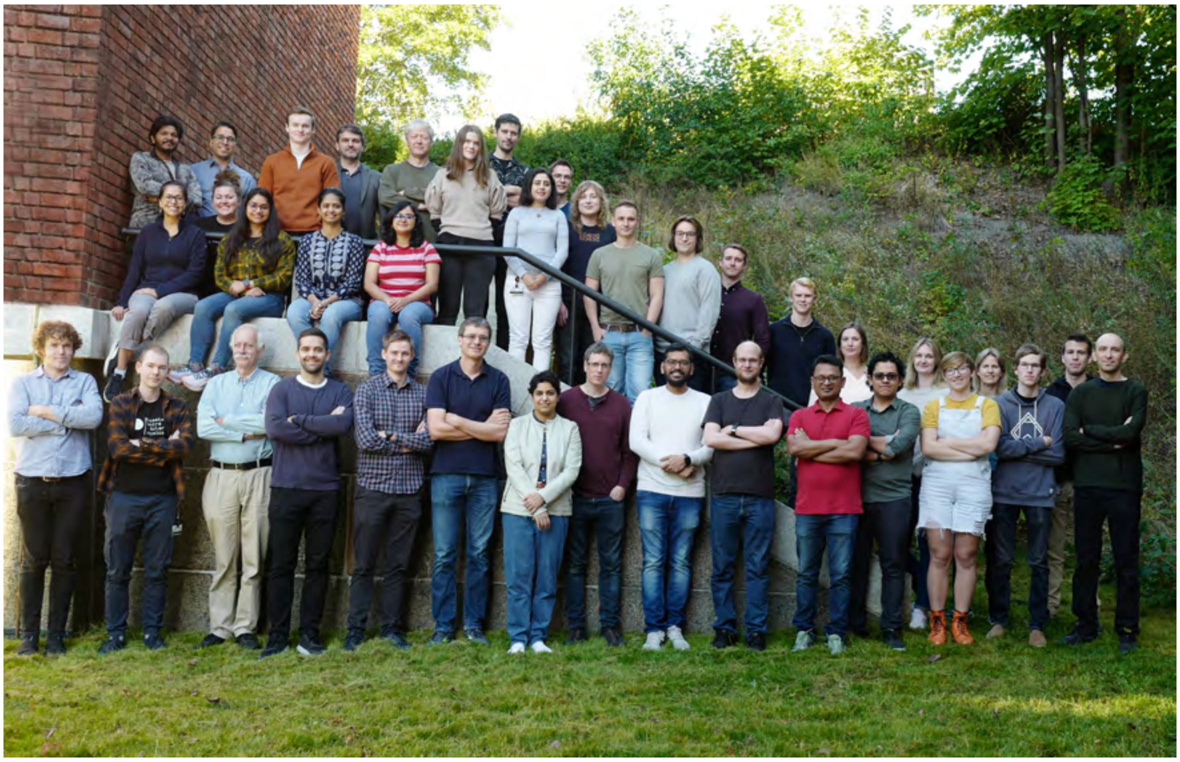
Our vision is
understanding
the workings of the
energetic Sun.

1. To understand the origin and evolution of the solar magnetic field on spatial scales ranging from the smallest observable (<100 km) to the size of active regions (100,000 km).

2. To understand the dynamic structuring and mass and energy transfer in the solar atmosphere from the relatively cool (6,000 K) surface to the multi-million degree corona.

3. To understand which configurations of the magnetic field, ambient and emerging, lead to the development of dynamic phenomena such as surges, jets and flares of all sizes that permeate the active solar atmosphere.

4. To go beyond the single-fluid magnetohydrodynamic (MHD) paradigm, which breaks down in the nearly neutral chromosphere and the almost collisionless coronal plasma. We will do this by applying multi-fluid and particle-in-cell techniques, providing new understanding of heating and particle acceleration in both quiet and active solar environments.



Members of RoCS on a sunny day in September 2022 outside the Institute of Theoretical Astrophysics. Credit: Ola Gamst Sæther

From the Director

This is the fifth annual report of the Rosseland Centre for Solar Physics (RoCS). The centre is one of the 10 centres of excellence selected by the Research Council of Norway in the fourth round of the centres of excellence scheme.

In 2022 we celebrated the 5th anniversary of RoCS on November 1st. We are thus more than halfway through the 10-year funding as a centre of excellence. Building up a new centre is a complicated process, and it took quite some time in temporary offices before our newly renovated premises were ready. The moving into the RoCS home coincided with our 2nd anniversary in 2019 and only four months later, the pandemic interfered with our grandiose plans. Thanks to hard work from a lot of people, we managed to adapt to the changes in boundary conditions and we were even able to get our international hires to Norway. The Covid-19 pandemic finally subsided in 2022 and we are getting back to working and travelling conditions from pre-covid times. Our activity at RoCS is very international with extended collaborations with fellow researchers from all over the world. Also within RoCS we are dependent on close collaborations. Being able to meet again at international venues and in the offices of RoCS means a lot for all of us and our activities.

Our contract states that we have a 6+4-year funding with a mid-term evaluation to determine whether the funding would be given for the last four years. Instructions on the required documents were late, but in November we were gathering information to complete the self-evaluation and other documents. The first two months of 2023 were booked for intensive work towards the deadline of March 1st. We were quite surprised (but also relieved) when we received a message just before Christmas that the mid-term evaluation had been cancelled and all centres will be prolonged for the full 10 years. The reason for the cancellation of the evaluation is that the Research Council of Norway is undergoing a full restructuring and has suffered severe budget cuts. They simply did not prioritize a process that with all likelihood would have had the same result in the end (in the previous three rounds of centres of excellence in Norway no centre was stopped as a consequence of the mid-term evaluation). We will pursue the parts of the evaluation preparations

In 2022 we were a total of 71 persons of 21 nationalities from four continents at RoCS.

that are important for the centre; like working on a revised project plan and negotiating with the University, Faculty and Institute for the plans after the end of the centre funding.

The retreat in Strömstad, Sweden, in May 2022, had two parts. In the first, we discussed the follow-up of the retreat 2021 on working culture. The second part was on the main research goals of RoCS and how we are working towards them. The participants were divided into small groups where all gave a short oral presentation of what they were working on and how that matched with the RoCS vision and sub-goals. Groups were reshuffled and the process repeated until each had been in a group with most of the others. We learned a lot about what is going on in RoCS and had very nice discussions.

In November we had our second gathering, now in our own premises. We had four science topics as themes with an introductory talk and thereafter discussions in groups. The science topics were "Magnetic field generation and emergence "(introduced by Mikolaj Szydlarski), "Heating of the Solar Atmosphere" (introduced by Luc Rouppe van der Voort), "Energetic events and ejections" (introduced by Boris Gudiksen) and "Solar and Stellar Magnetism" (introduced by Sven Wedemeyer). Very lively group discussions followed each introductory talk.

RoCS has increased in size in 2022. Four additional postdocs started: Nicolas Poirier on the ORCS project (for an overview of projects within RoCS, see page 26), Carlos José Díaz Baso on the ISSRE-SS project, Reetika Joshi on a general RoCS grant and Quentin Noraz on the WholeSun project. Four new PhD students started: Jonas Thoen Faber and Elias Roland Udnæs with RoCS funding and George Cherry and Ignasi Poquet in the "CompSci: Training in Computational Science" doctoral program, partly funded by the EU Horizon 2020 under the Marie Skłodowska-Curie Action (MSCA) - Co-funding of Regional, National and International Programmes (COFUND). We got five new master students: Tor Andreas S. Bjone, Christophe K. Blomsen, Aline R. Brunvoll, Eloi Martaille, and Semya Amouche Tønnesen. As well as many new coming in, we also have people moving out. Nancy Narang finished her post-doc period in December and is moving to the Royal Observatory of Belgium, Souvik Bose moved to Palo Alto and started working for the Lockheed Martin Solar and Astrophysics Laboratory, Juan Camilo Guevara Gómez defended his PhD thesis and Ilse Kuperus and Marte Cecilie Wegger finished their Master's. Best wishes to all in their careers.

The activity has been high in 2022 and reports, organised by theme, are given in Section 2. A list of talks and presentations is given in Appendix 1 and a full list of the 60 papers published in refereed journals in 2022 in Appendix 2.

Research results are important, but it is also essential to communicate these results to both the scientific world and the society at large. Our full-time communication advisor, Eyrun Thune, has been very active in promoting solar physics together with the RoCS crowd. You can read more about this important activity on page 28-33.

The International Rosseland Visitor Programme, ramping up in 2022, is covered in Section 3 and we continue the tradition with some glimpses from the life at RoCS in Section 4.

As the most important part of a centre is the people, we have short presentations of all the members in Section 5. In 2022 we were a total of 71 persons of 21 nationalities from four continents at RoCS.

At the time of writing, we are busy preparing for our first major, in-person, international scientific meeting organised by RoCS. The RoCS-MUSE-IRIS (shortened RoCMI) workshop will have 100 participants meeting in Longyearbyen on Svalbard at 78 degrees latitude on February 27 to March 2. It is clear that in-person meetings have been missed in the community – we filled up the available capacity very quickly and 31 out of the 32 invited speakers accepted the invitation with enthusiasm even though there was no funding accompanying the invitation. Svalbard was chosen as the location because most of the IRIS data is downlinked at the SvalSat station and we are planning for a similar effort for the upcoming MUSE mission (scheduled for launch in 2027).

Back to a new normal, I hope we can take advantage of the experiences with on-line meetings and remote working but also meet in person on a regular basis.

February 2023

Mats Carlsson,
Director of RoCS

2022 Activities by theme

Credit: Aditi Bhatnagar

Simulations

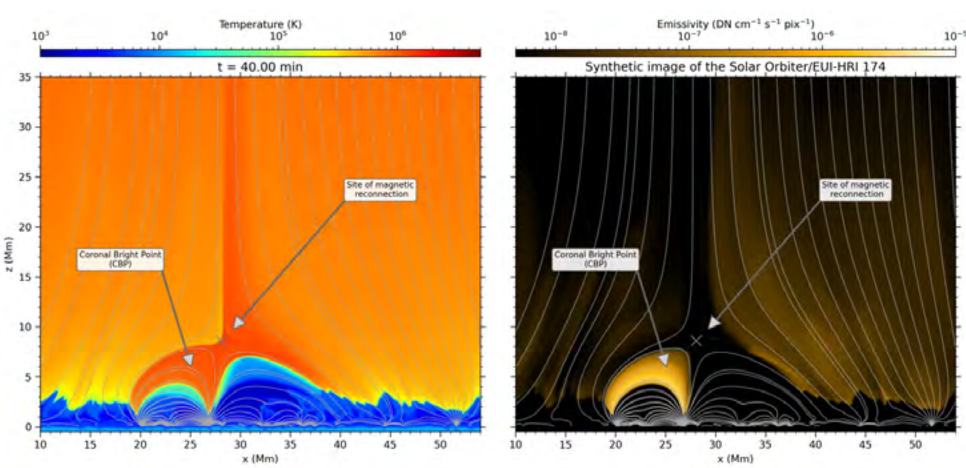
The goal of RoCS is to better understand the active Sun. In practice, this means understanding how the Sun's magnetic field interacts with the plasma, or gas, that is the solar atmosphere. It is the magnetic field that is the engine that drives flares, coronal mass ejections, jets and surges, forms filaments and prominences, and a host of smaller, but no less important phenomena that characterise the active energetic Sun.

This interaction goes both ways: in the convection zone, below the solar surface, it is the gas that kneads and deforms the magnetic field, in the regions above it is the other way around and the magnetic field forms and drives the chromospheric and coronal plasma. In 2022 both these aspects have been investigated.

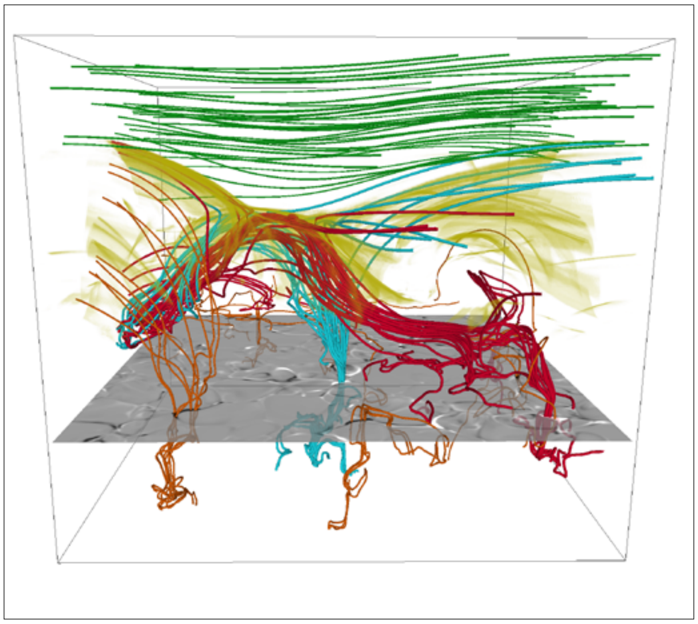
The convection zone not only deforms the magnetic field, it is becoming increasingly clear that convective motions also form a "local" dynamo, generating or strengthening new magnetic field perhaps independently of the global dynamo that is responsible for the 11-year sunspot cycle. By examining the flow of plasma we can gain a better understanding of the dynamics of the sun, including how it generates and maintains its magnetic fields. In a figure below we show a vertical cut from a deep simulation of convection and convective motions that illustrates how convective scales get larger from the typical 2000 km sized granules as we descend into the deep convection zone. Perhaps such models can assist in explaining the 20 to 30 thousand km size scale of the chromospheric magnetic network?

Both globally and locally generated fields will, when strong enough, break through the solar surface and emerge into the outer solar atmosphere, violently energizing the plasma as the new fields reconnect with the already existing ambient field. Even without flux emergence, convective motions will tangle, or braid, the ambient coronal field causing reconnection and heating of plasma in so-called nanoflares; in the figure below we show one such event modelled with Bifrost where we measure temperatures rising up to 1.5 million degrees.

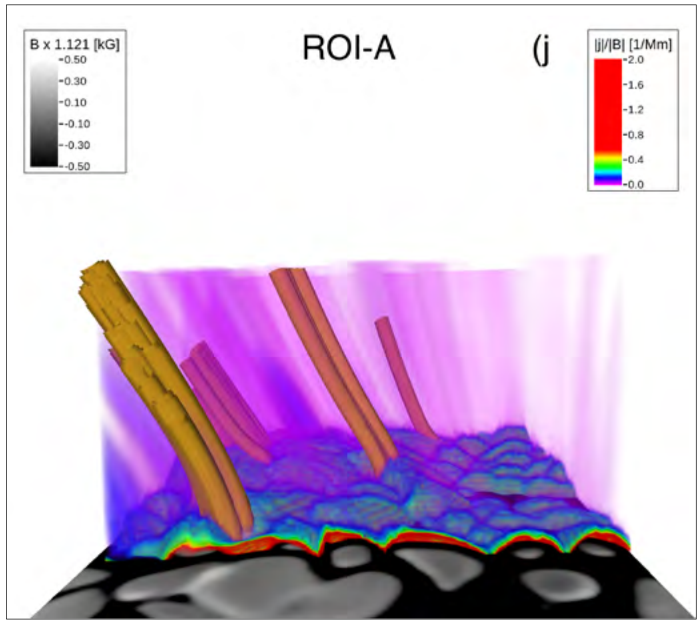
As an illustrative example of the possible effects of flux emergence, we present a study of a coronal bright point (CBP). Using the Bifrost code we have for the first time modelled the phenomena with enough realism to unravel the mechanisms that generate them and provide them with energy. Synthetic images for SDO/AIA, Solar Orbiter EUI-HRI, and IRIS, generated from the simulations show remarkable similarities with the real solar data.



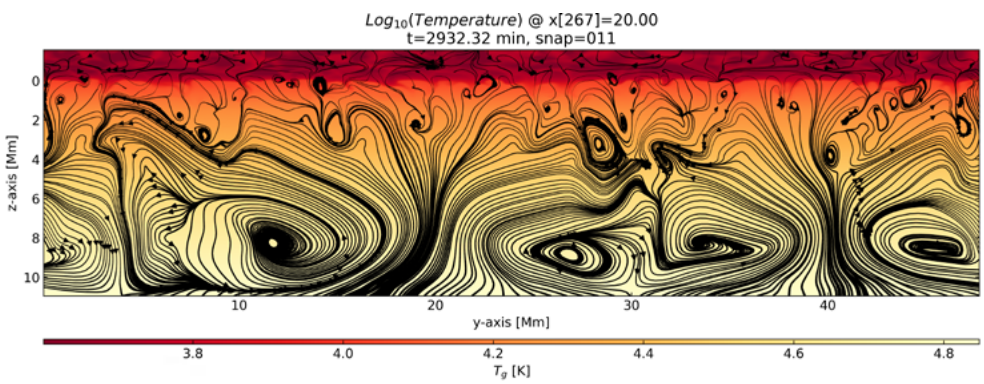
Results of the recent 2D model of coronal bright points (Nóbrega-Siverio and Moreno-Insertis, 2022 https://ui.adsabs.harvard.edu/abs/2022ApJ...935L..21N). Left: temperature. Right: Image showing how the simulation would look like if observed with the Solar Orbiter mission in the extreme ultraviolet from space. The coronal bright point is distinguished by the hot magnetic loops that appear bright in the right panel.



This figure illustrates several different magnetic features that form before the onset of a quiet Sun heating event. A magnetic arcade (cyan lines) and flux rope (red lines) are in the process of reconnecting with a nearly anti-parallel horizontal field in the corona (green lines). The orange lines represent flux bundles that are not directly involved in the reconnection, but still exist during the reconnection. A volume rendering of Joule heating (yellow) highlights the reconnection region and resulting bi-directional jets.



Visualization of the current sheets (j/B) traversing the photosphere to the corona due to braiding of the magnetic field lines in a simulated "plage". The field lines that are associated with the strongest current sheets are indicated in brown. The vertical magnetic field map at z=0 is shown in the background. The displayed field-of-view of the simulation covers an area of 10,000 X 10,000 square km.



The figure represents a 2D stream plot of the velocity of plasma flows below the Sun's surface. The plot was generated from a 3D solar simulation with dimensions of 48 x 48 Mm and a depth of 11 Mm. The stream plot visualises complex patterns and directions of plasma flow in the sun's interior.

When sunspots get old they are no longer able to resist the turbulent buffeting of convective motions and are broken apart into large, spread out, magnetic patches called plage. The magnetic field in these regions is still strong enough to hinder fully fledged convection, so the heating of plage remains a mystery. The magnetohydrodynamic simulation of the active region plage has been performed using the Bifrost code in a 3D computational box, spanning from the convection zone 8.5 Mm below the photosphere to the high corona 52.5 Mm above it. The major goal of the analysis was to understand the reason behind the correlation in heating of the solar chromosphere and the corona in the so-called "moss" regions of the solar atmosphere, observed with coordinated IRIS and HiC 2.1 instruments. Synthetic observations derived from the numerical simulation bore a striking correspondence with real observations, implying the presence of a common heating mechanism prevailing in the chromosphere and the corona. Dissipation of current sheets caused by braiding of the magnetic field lines (as explained in the figure above) was responsible for simultaneously heating the plasma in the chromosphere and corona.

Viggo Hansteen

Observations with SST and IRIS

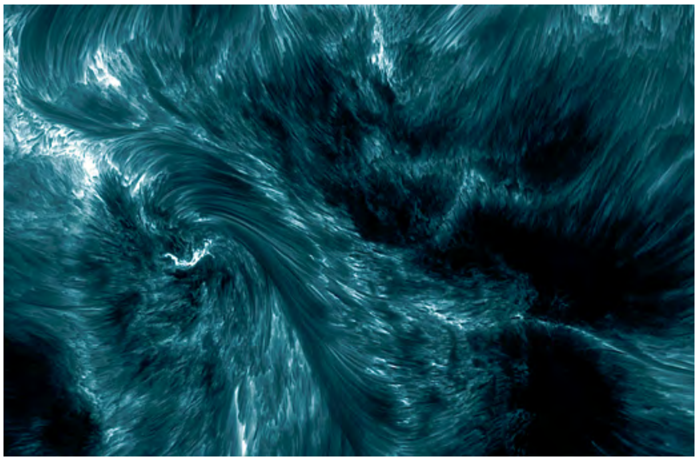
RoCS is the largest external user of the Swedish 1-m Solar Telescope (SST) at La Palma in the Canary Islands. All observations are coordinated with the IRIS satellite so that we have dense coverage of the solar atmosphere from the photosphere up through the chromosphere and transition region into the corona.

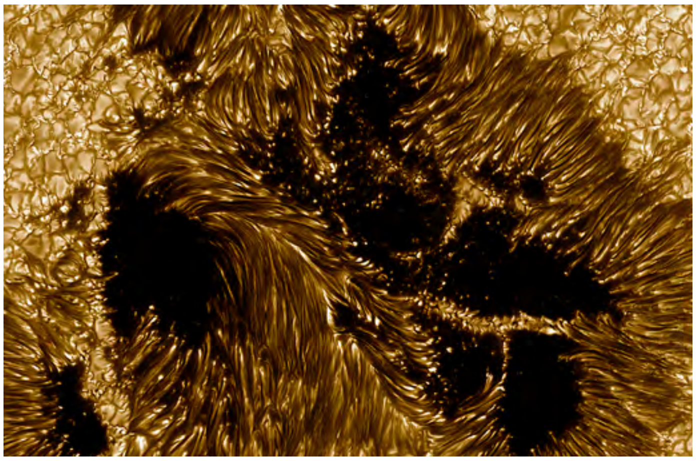
For many years we have an agreement with the Institute for Solar Physics in Stockholm which gives us observing time at the SST. The observing time is usually divided over three campaigns spread over the observing season. In 2022 these campaigns were in May, June/July, and September. All Covid travel restrictions were lifted and we could have full observer teams at the SST. For many RoCS members, this was their first visit to SST and La Palma. In total there were 11 RoCS members participating in the three campaigns, the photos on page 40 give an impression.

A very active Sun

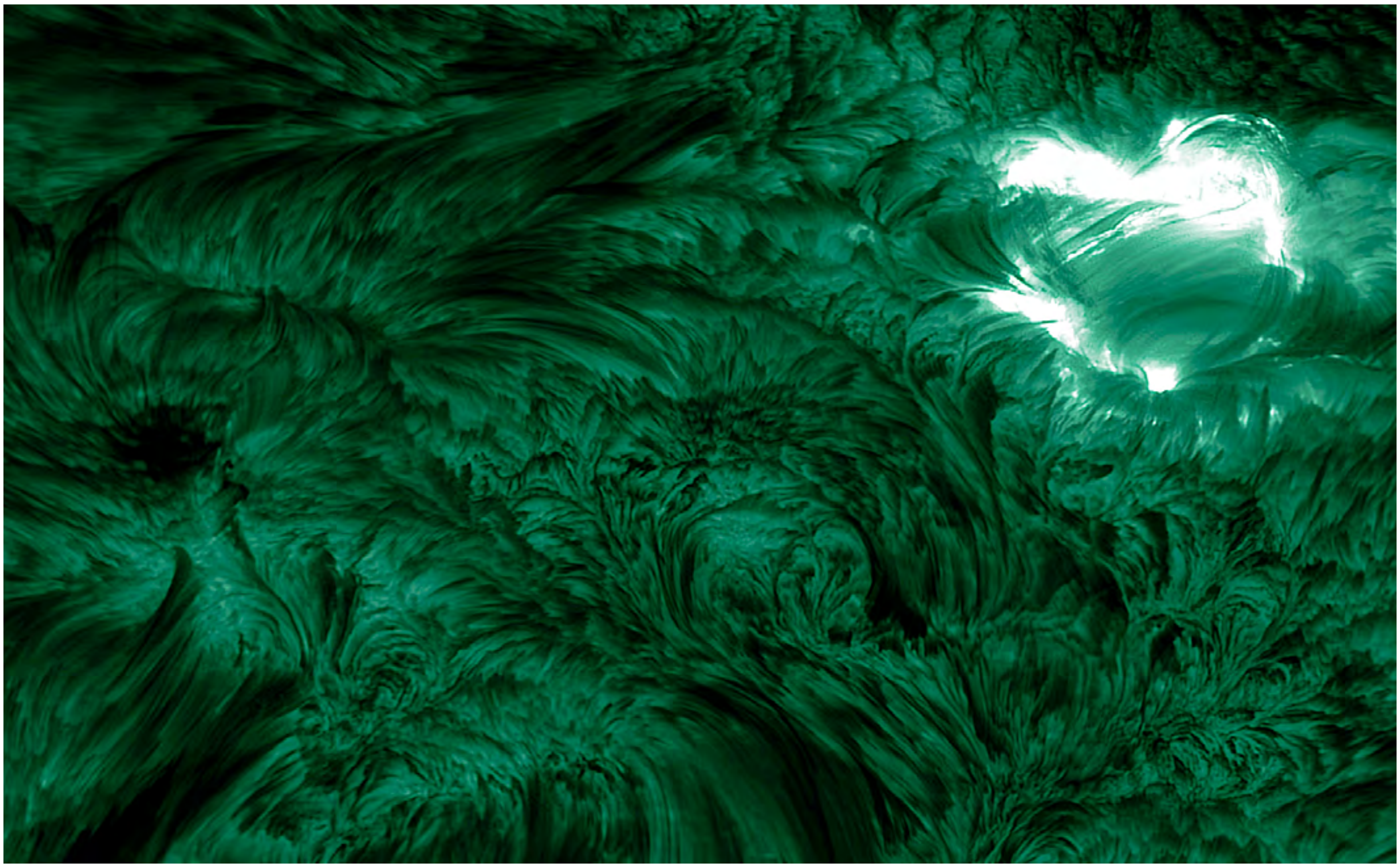
The Sun is clearly increasing in activity level as compared to previous years, there were ample active regions during all three campaigns. During the May campaign, we observed the giant Active Region 13014 under very good seeing conditions (see the figure below). It was so big that the main sunspot did not fit the SST field of view (about 1 arcmin x 1 arcmin). The sunspot was very complex with extended irregular penumbrae and different types of light bridges crossing the umbrae.

During the June/July campaign, we were particularly lucky with the weather conditions and we had several days with extended periods of good seeing. This allowed us to observe several small flares of B and C class magnitude. The figure on the next page shows an H-beta line core observation during the peak of a C 1.5 class flare. It was a confined flare and did not result in a massive outburst. Still, it showed a lot of complex and rapid evolution in the 7 second cadence H-beta observations that were recorded under very good and stable seeing conditions. Two days later, we were lucky





Trailing spots in monster AR13014, one of the largest active regions of the current activity cycle. Observed on 21 May 2022.
Left CHROMIS WB 3950 Å, right Ca II H 3968 Å line core.



H-beta 4861 Å line core image of the C1.5 class flare on 24 June 2022.

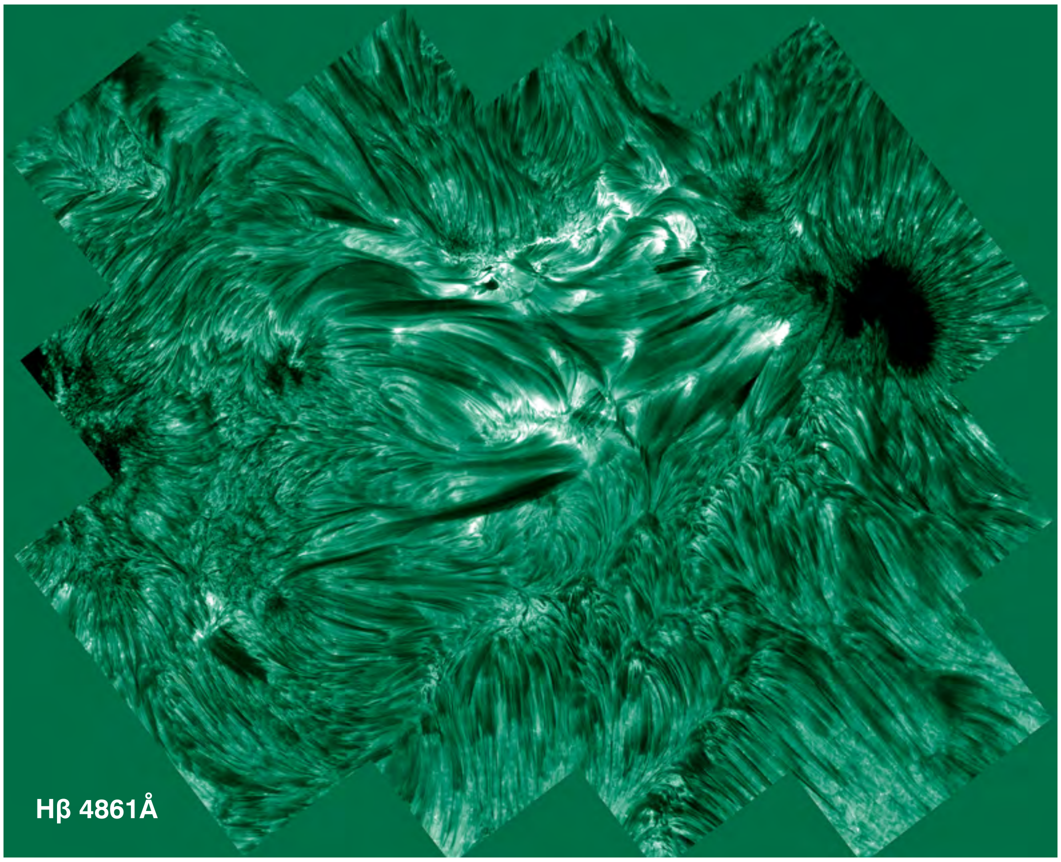
to capture a double peaked C class flare that resulted in a massive eruption. This flare was also covered very well with IRIS and SDO. This unique dataset is now the basis for the PhD project of Jonas Thoen Faber who started in the the fall of 2022. Another two days later, we were fortunate to encounter some of the best seeing conditions of the whole season. PhD student Kilian Krikova was particularly happy: he had just arrived for the first time at the SST and he was already part of capturing spectacular emission in the H-epsilon spectral line in a massive Ellerman bomb. Kilian is studying the formation of this spectral line for his PhD project. We also acquired a number of mosaics of larger areas on the Sun. The SST telescope control now offers an observing mode that moves over a grid of pointings covering an extended field of view. This allows study of larger scale magnetic connectivity after constructing a mosaic of the different pointings. A nice example of a mosaic of a large active region is shown on pages 14 and 15.

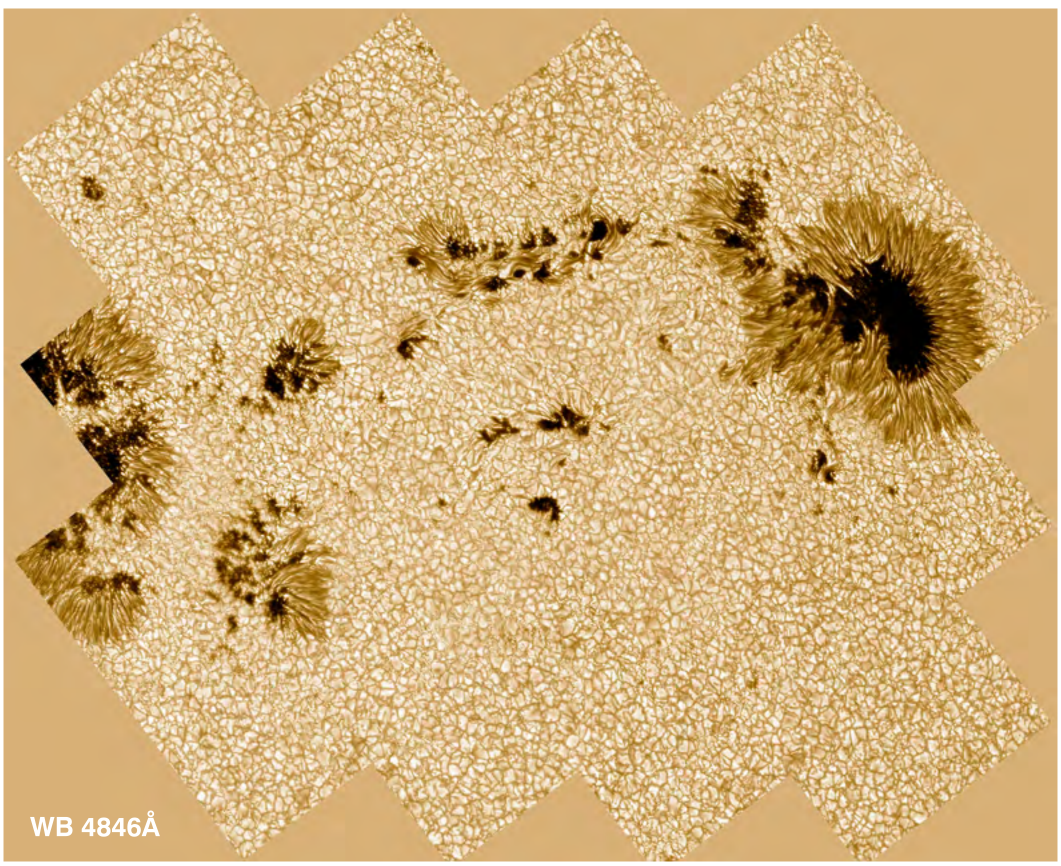
All in all, the June/July campaign was unique with so many days of good seeing. We recorded in total 78 TB of raw data and this resulted in almost 25 hours of processed time sequences.

New CRISP cameras

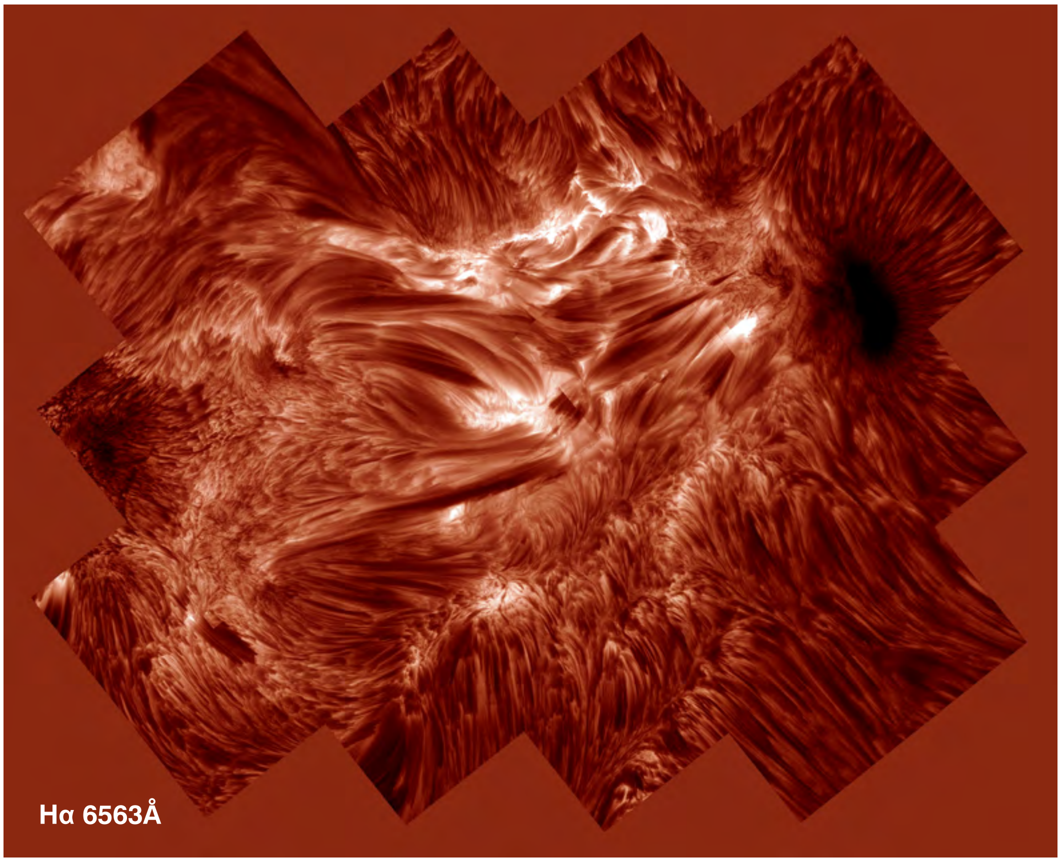
During the September campaign we acquired our first observations with the new cameras for the CRISP instrument. These new cameras give a considerably larger field of view: almost 1.5 arcmin diameter circular area as compared to the old 1 arcmin square area. This upgrade enables CRISP to much better capture large scale dynamics such as flares in active regions. The cameras can also operate at considerably higher frame rate which will also allow better image quality after image restoration. We captured a nice 50 min time sequence of a coronal bright point which appeared as a small bipolar region, nicely covered in the large CRISP field of view. It is clear that the new cameras expand the capabilities of CRISP and consolidate the SST's leading position as a prime telescope for high resolution solar observations.

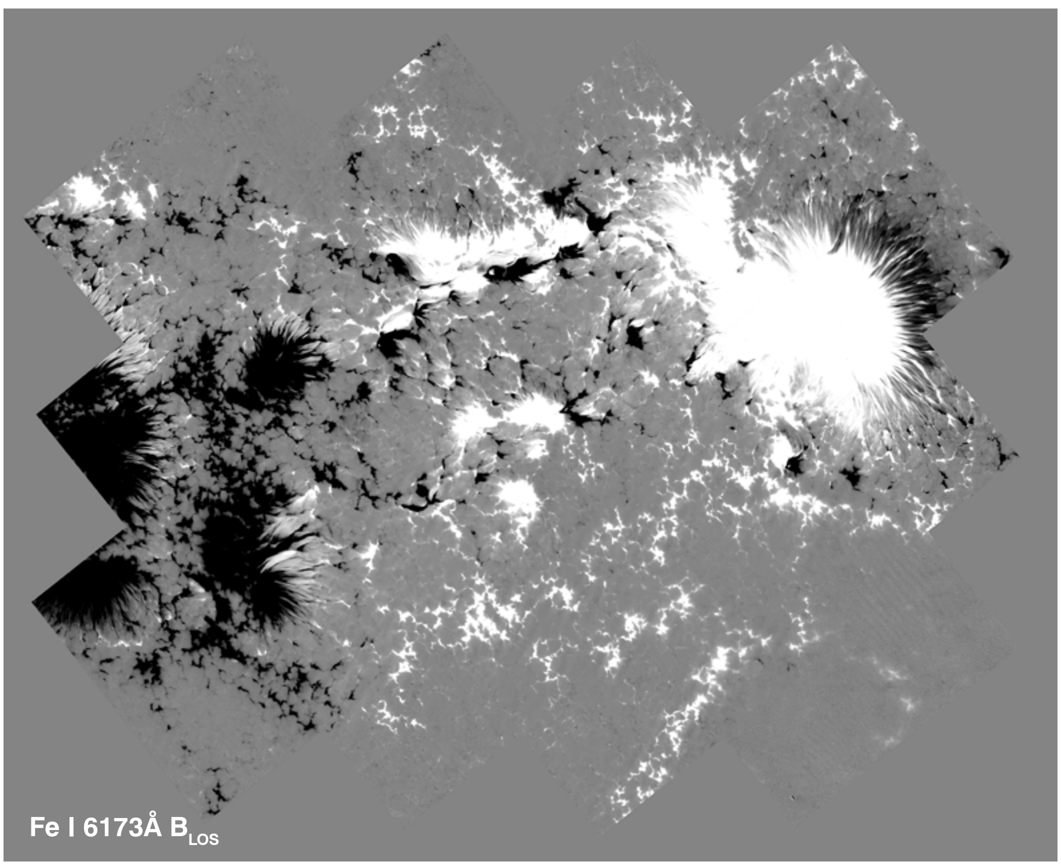
Luc Rouppe van der Voort





Active Region 13038 observed with SST on 22 June 2022. The mosaics were constructed from a 4x3 grid of pointings.


Hα 6563Å

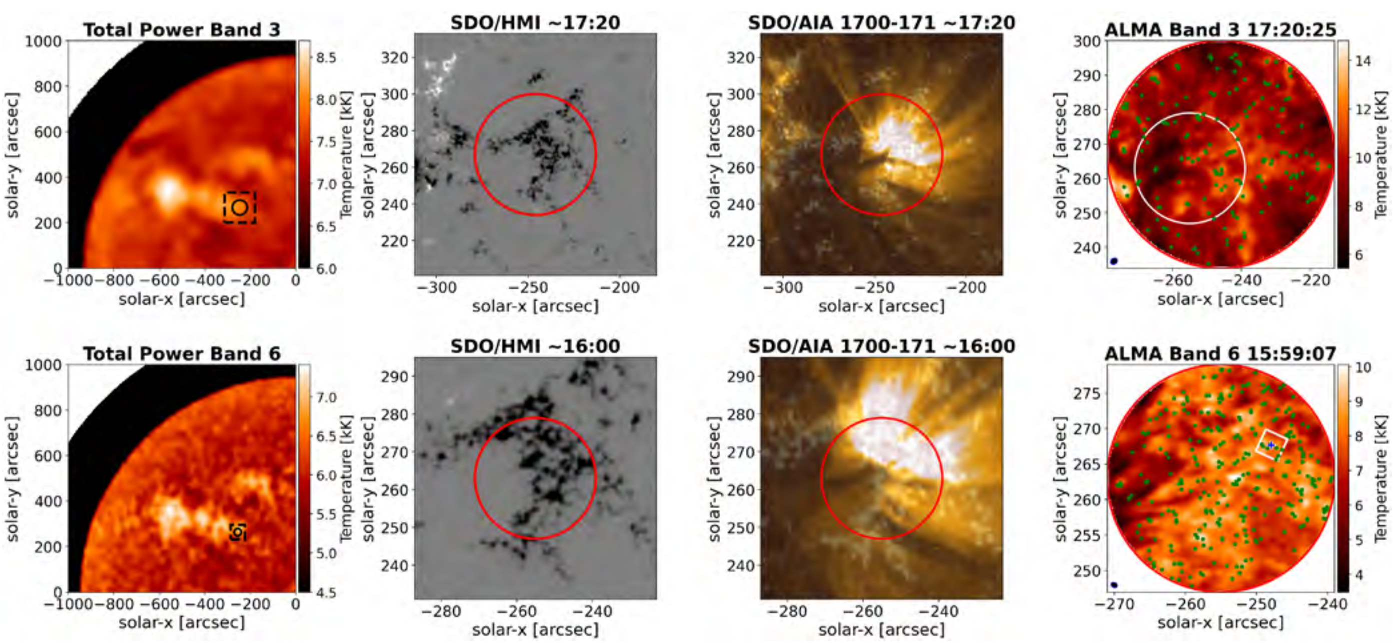

Fe I 6173Å B_LOS

Science with ALMA

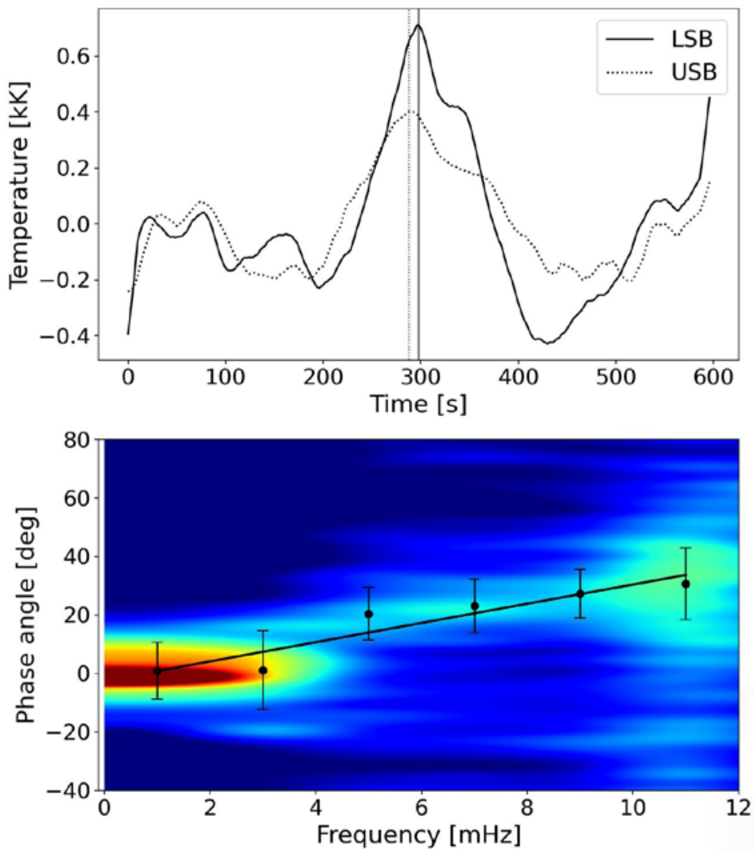
In 2022, the analysis of observational ALMA data, now available at the Solar ALMA Science Archive (SALSA) in Oslo, continued, while other major activities focused on the technical development of data post-processing techniques and future observing modes and on the activity of our Sun in comparison to other stars. Juan Camilo Guevara Gómez successfully defended his PhD thesis with the title *“Observations of the dynamics and structure of the solar atmosphere with ALMA”*.

Unlocking the spectral domain

While the set-up of solar observations with ALMA comprises 4 x 128 spectral channels, the standard procedure so far is to combine the information from all channels into one continuum map per time step. This approach, which then produces a time series of “continuum maps”, is motivated by the aim to produce high-quality images despite the limited available data measured across ALMA’s antenna baselines at a high cadence. The frequency dependency of the data is lost in the process but contains valuable information. As the height from where the radiation emerges at millimetre wavelengths depends on frequency, the corresponding frequency-dependence of the spectrum, i.e. in first order the slope of the brightness temperature continuum, contains information about the local height dependence of the thermal structure of the Sun’s chromosphere and its dynamic variations. As demonstrated based on numerical simulations with Bifrost, exploiting this information would substantially boost ALMA’s diagnostic potential beyond today’s possibilities (Eklund et al).



ALMA observations of the Sun in Band 3 (top) and Band 6 (bottom), left to right: ALMA Total Power map with target region, SDO/HMI and SDO/AIA 1700-171, and ALMA interferometric brightness temperature map. The green dots in the rightmost column mark the detected small-scale magnetic features with oscillatory behaviour.

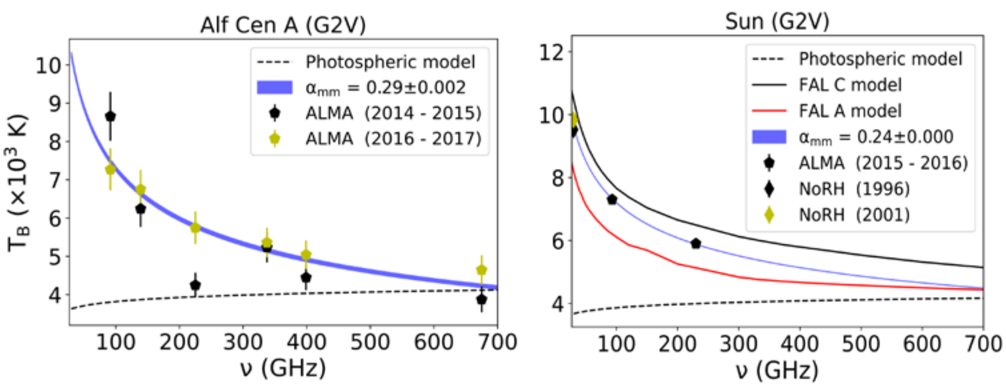


Top: Brightness temperature as function of time for a selected position in an ALMA observation of the Sun split into two frequency bands. Bottom: Phase angles between the signals in the two bands. (Guevara Gomez et al. 2022)

Waves and oscillations

An important application for solar observations with ALMA in 2022 was the study of different types of propagating waves and oscillations, enabled by ALMA's high temporal resolution. A new algorithm for the automatic detection and tracking of bright small-scale features was developed and applied to ALMA observations of a plage/enhanced network region, and for comparison also to corresponding artificial observations based on a Bifrost simulation (Guevara Gómez et al). The magnetic nature of the detected features was confirmed and an oscillatory behaviour in temperature, size and horizontal velocity was found. These results indicate the possible presence of propagating transverse (kink) and compressible fast sausage magnetohydrodynamics (MHD) wave modes. Interestingly, the latter are estimated to potentially carry an energy flux that is significant in the context of chromospheric heating. The estimated flux in Band 3 is lower than for Band 6, which implies a decrease of the energy flux with height, consistent with what would be expected for wave heating.

The ability to observe the chromosphere at different heights simultaneously has a particularly large potential for studies of waves, oscillations and related chromospheric heating. The necessary observations can in principle be done with ALMA if the frequency domain is exploited as mentioned above. As a first application, ALMA Band 3 data was split into a lower and an upper sideband and then processed with the Solar ALMA Pipeline (SoAP), resulting in two sets of time series of brightness temperature maps for each side-band (Guevara Gómez et al). For the quiet Sun part of the observed region, the average height difference between the two side-bands is estimated as 73 ± 16 km. A wavelet analysis of this unique data set then revealed the propagation of transverse waves in small-scale bright structures with different properties and a combined energy flux of 3800 Wm^{-2}, which again is highly significant as a potential contribution to heating the outer atmosphere of the Sun.



Determination of the new activity indicator α_{mm} as spectral index of the brightness temperature spectrum for the solar-like star Cen A (left) and the Sun (right) (Mohan et al. 2022).

ALMA's diagnostic potential for wave studies can be further increased when combined with data from space telescopes such as IRIS and SDO. A detailed investigation of the power distribution of oscillations in a plage region produced unexpected results (Narang et al). Except for similarities with some transition region and coronal passbands of SDO/AIA, the oscillatory behaviour observed with ALMA did not match corresponding observations in other SDO/AIA passbands. A likely explanation is that the formation height range of the millimeter continuum is more variable and extended than previously thought. Understanding these findings is a major challenge that must be overcome to further develop ALMA as a reliable diagnostic tool for the solar chromosphere.

Optimising the imaging procedure

In 2022, the ALMA development study "High-cadence Imaging of the Sun" entered its final phase. The impact of Earth's atmosphere above the ALMA site was studied and applied to artificial ALMA observations of the Sun based on a Bifrost simulation. Image time series were produced for larger grids across different imaging parameters and different weather scenarios and then compared to an ideal reference case, facilitating the quantitative assessment of the data quality and optimizing the choice of parameters accordingly (Wedemeyer & Szydlarski).

Future observatories

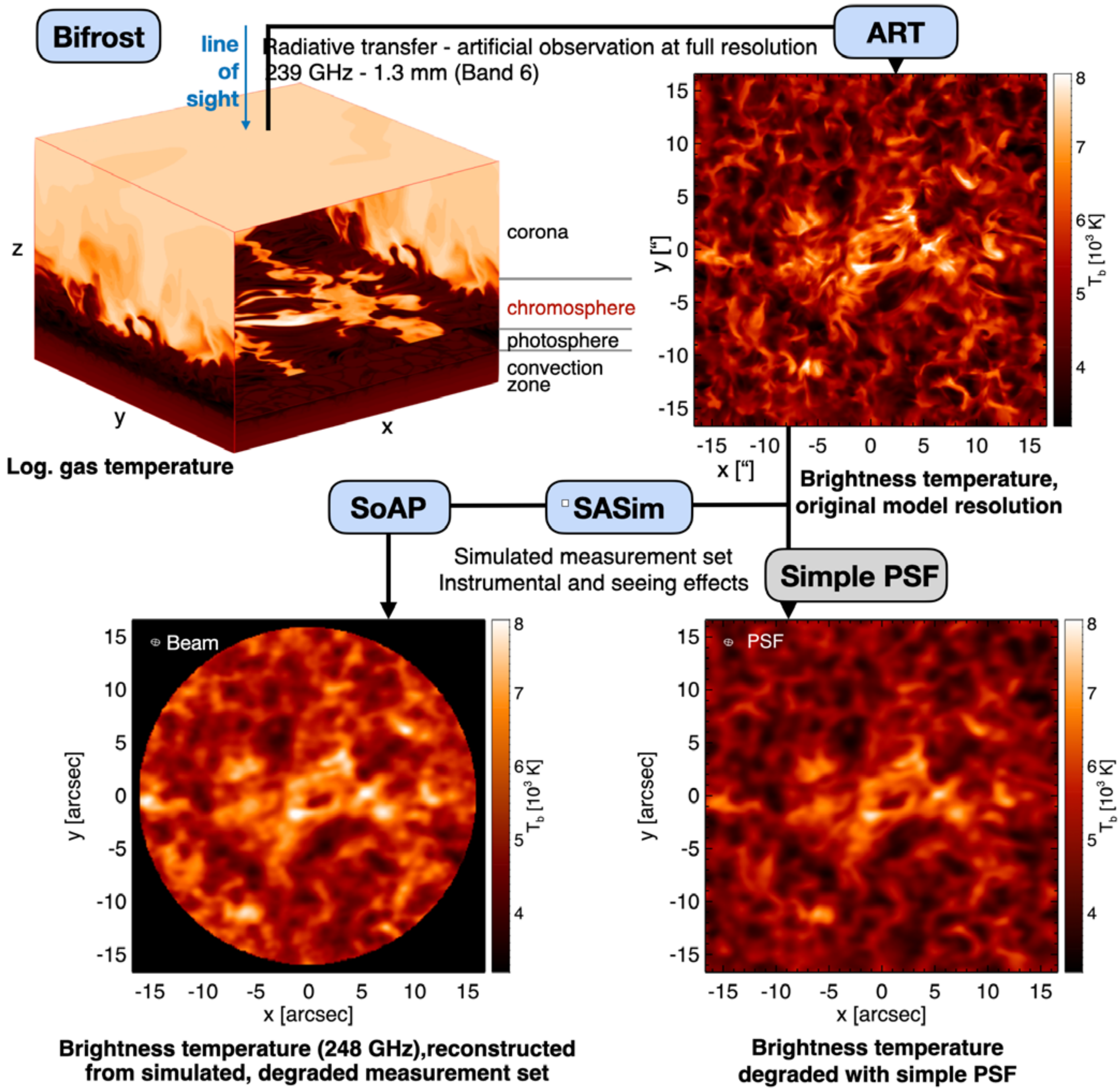
The Atacama Large Aperture Submillimeter Telescope (AtLAST[1]), which is in its initial design phase, would be a 50m single-dish telescope capable of observing the Sun. In collaboration with international colleagues, the RoCS ALMA group developed potential science cases for AtLAST that range from synoptic (long-term) observations of the Sun to capturing solar flares.

The solar-stellar connection

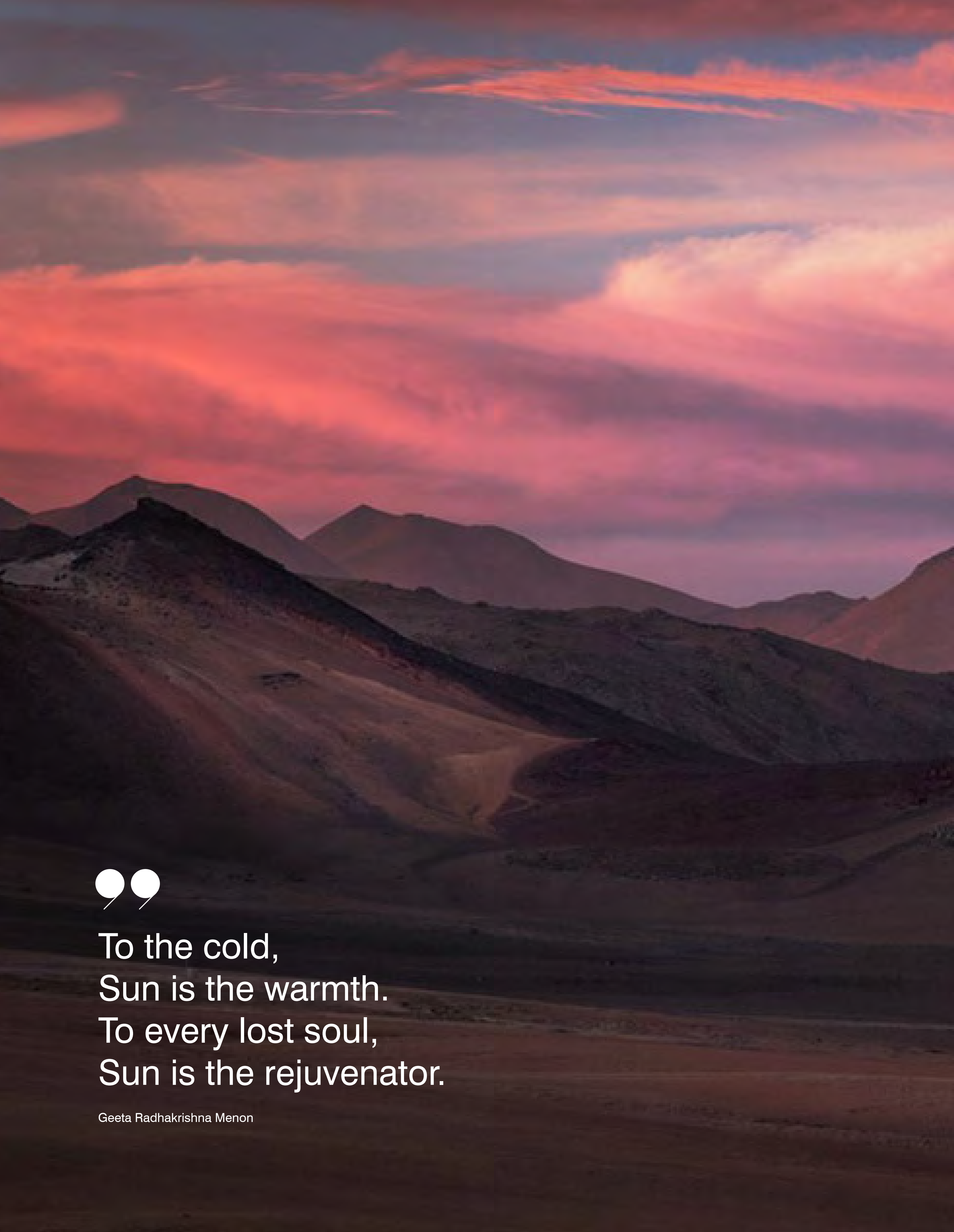
The sample of cool main-sequence stars compiled in the EMISSA project facilitated the development of a new robust activity indicator, namely the spectral index α_{mm} of the brightness temperature spectrum in the frequency range of 30 GHz -1 THz (Mohan et al.). The indicator is linked to the thermal stratification and activity of cool stars and thus to the existence of a chromosphere. This new indicator performs better than other activity indicators in the sense that it can successfully distinguish cool stars with otherwise similar properties. The further development of the mm brightness temperature as activity indicator, in comparison to other commonly used (e.g., Hα and Ca II indices) with the Sun as an essential reference case, is currently in progress (Pandit et al.). The efforts are complemented with the compilation of a large stellar catalogue and numerical simulations for different stellar types as part of two ongoing M.Sc. projects (Kirkaune, Thrane). Finally, for the first time, aluminum monofluoride was detected in the spectra of M-type AGB stars, shedding light on the nucleosynthesis and chemical evolution of evolved stars (Saberi et al).

Sven Wedemeyer

1) The design study for AtLAST is coordinated by the University of Oslo and is supported by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 951815. https://www.atlast.uio.no



Simulated ALMA observations of the Sun based on 3D Bifrost simulations (Wedemeyer et al. 2022)



To the cold,
Sun is the warmth.
To every lost soul,
Sun is the rejuvenator.

Geeta Radhakrishna Menon

Views of the Atacama dessert at the ALMA site. (© ESO)

Code Development

In 2022, we developed the capability to simulate the whole convection zone of the Sun. This capability draws on the computational capability of the DISPATCH framework and is described in a separate section.

We now have three numerical tools of world-leading quality, making it possible to simulate the whole solar convection zone, then zoom in on a location with an interesting magnetic configuration, make a detailed simulation of the atmosphere using Bifrost, and finally use the output to calculate synthetic spectral observations of the atmosphere making it possible to compare directly with the high-quality observations we have available from ground and space based observatories. The ability to do this in-house makes RoCS a standout centre.

RoCS was born to investigate the active Sun and the ultimate goal on the modelling side was to produce a model that could cover a whole active region and a solar flare, including both the necessary physics and the necessary physical scales to produce a realistic result. The physics can be modelled by a fluid description on large scales, but a fluid description breaks down in the kernels of solar flares where smaller length scales are important. The ability to employ multi-scale and multi-physics in our simulations of the active Sun is therefore a central goal for RoCS. This work has progressed through 2022 and we are now on the brink of running a simulation of the kernel of a solar flare employing a particle description instead of a fluid description. The first successful test was completed during the year and communication and memory optimizations are now being explored. The particle physics capability is developed to be part of the DISPATCH framework, so we will be able to couple MHD and particle simulations seamlessly in a so-called adaptively embedded particle in cell magneto-hydrodynamics simulation.

Bifrost is continuously being improved and has been used as a test-code in the Pilot phase of LUMI, the largest supercomputer in Europe and the third-fastest in the world. During the Pilot phase we worked on-site in Finland to adapt Bifrost to run efficiently on GPUs, the backbone of LUMIs impressive performance. The large change in hardware architecture is not necessarily easy for numerical codes to handle when they are written to be run on another type of hardware. GPUs have a much larger number of simpler compute cores. The change in hardware requires specialist knowledge to extract the highest performance, which RoCS has been fortunate enough to have through the scientific software engineers employed. The work done by Lupe (Maria Guadalupe Barrios Sazo) was the base of parts of the official Best Practices Guide for LUMI.

We have put an effort into preparing a public release of Bifrost. The pruning of non-essential parts as well as writing up to date documentation has taken time but also made it clear that a common post-processing architecture would be very useful. We are now working on routines that are able to read the very different data formats produced by Bifrost, DISPATCH and our spectral synthesis codes. Having a single interface to our data products makes it much easier to create common visualization and post processing tools. We have so far prototypes with common tools in IDL, Python, Julia and Rust.

Boris Gudiksen

Even great men bow before the Sun; it melts hubris into humility.

Dejan Stojanović

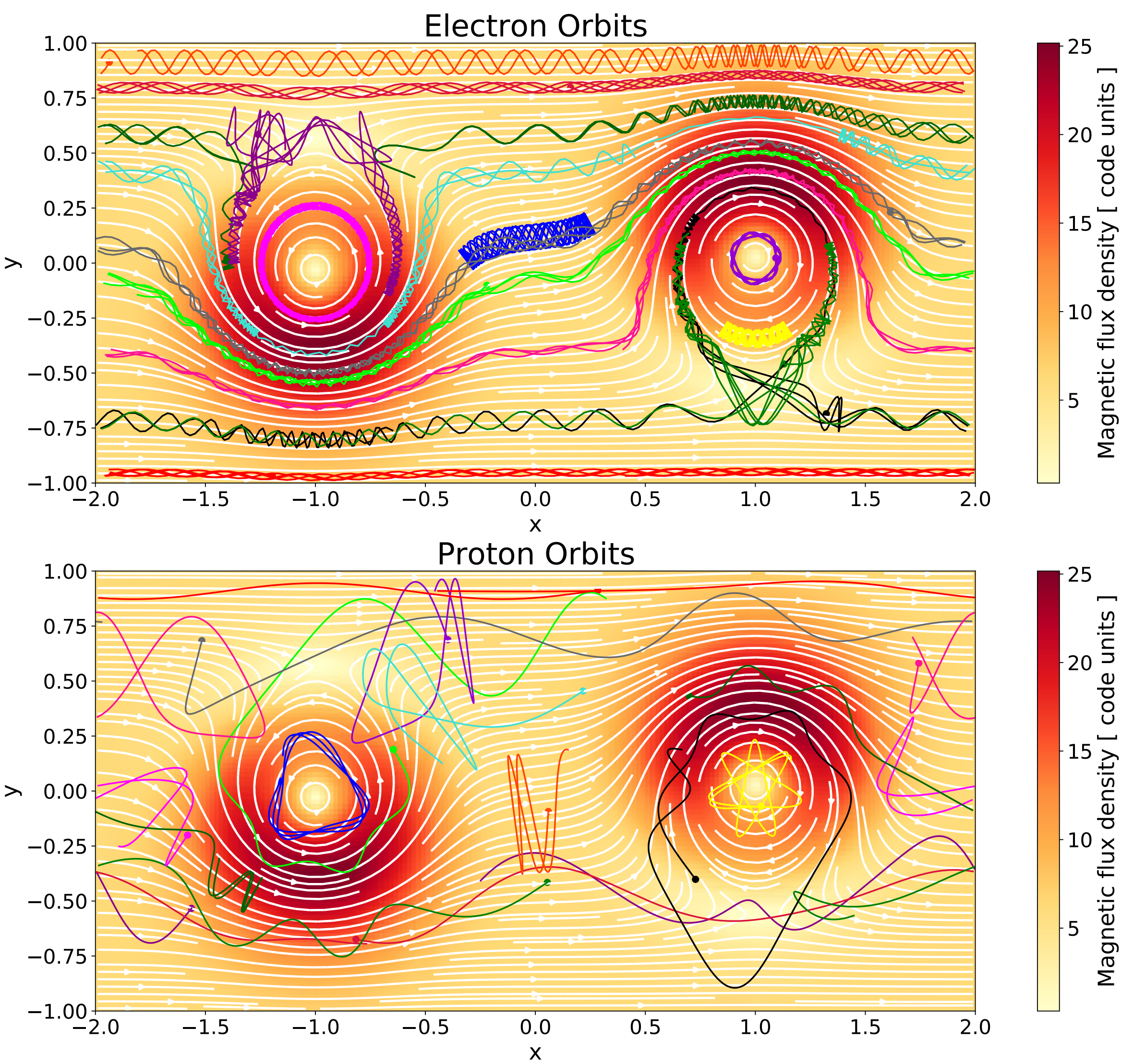


Figure: Example of a simple run with the newly developed particle in cell code. Magnetic field direction is indicated with white stream lines, while particle orbits are shown in different colors.

The Whole Sun with DISPATCH

Part of the ultimate goal, in the Whole Sun ERC synergy project, is to develop a code capable of carrying out global simulations of the Sun. Here at RoCS we do that within the DISPATCH framework (Nordlund et al., 2018). We utilise the main benefits of DISPATCH, namely local timesteps, local MPI communications, and overlapping Cartesian patches, to set up and run simulations covering an unprecedented range of scales.

Unique mesh decomposition

To simulate something in a sphere, one can use a number of different approaches. Most common are the use of a spherical mesh, or using a so-called “star in a box”. The former has problems with singularities at the poles, while the latter has difficulties maintaining exact spherical hydrostatic equilibrium.

To solve both problems while at the same time benefiting from cartesian arrangement for better vectorization and cache coherency, we use a unique, “Volleyball” decomposition, illustrated in Figure 1. As on a volleyball, the surface is divided into six identical faces. The faces are covered with small Cartesian patches, arranged along constant (local) latitudes. In practice, each such patch is of order one or a few megameters at the surface, while deeper layers are constructed with gradually increasing patch size (right panel in Figure 1). Each of the patches are then subdivided into for example 24^3, i.e. 24-cubed cells, making up the individual, and loosely coupled MHD-tasks to update. The updates can in principle be performed with any MHD-solver, but in order to minimise artificial numerical diffusion of entropy we use a newly developed, HLLS, Riemann solver, analogous to the common HLLD solver, but based on entropy rather than total energy.

The simulations

The set up currently spans 0.655-0.995 $R_\odot$, while in the future we will be able to include the solar surface and the core. We start with a hydrostatic equilibrium and let it relax to a steady-state convection. This relaxation period is performed with approximately 200,000 patches, with a highest resolution near the surface of approximately 500 kilometres. Figure 2 shows the relaxation in progress. Convection is well developed with very large cells visible 4 megameters below the surface. After the relaxation is complete we will refine several upper layers of the atmosphere (figure 3) by adding three levels of factor 2 refinement, to reach about 62.5 km resolution near the surface – only a factor of about 2-3 below a resolution sufficient to include the solar photosphere. This increases the number of patches in the simulation to about 4.5 million, containing about 70 billion cells.

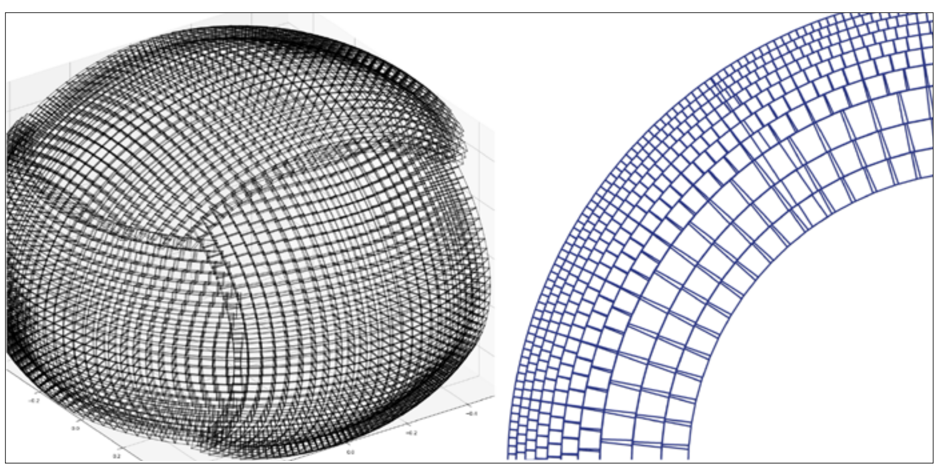
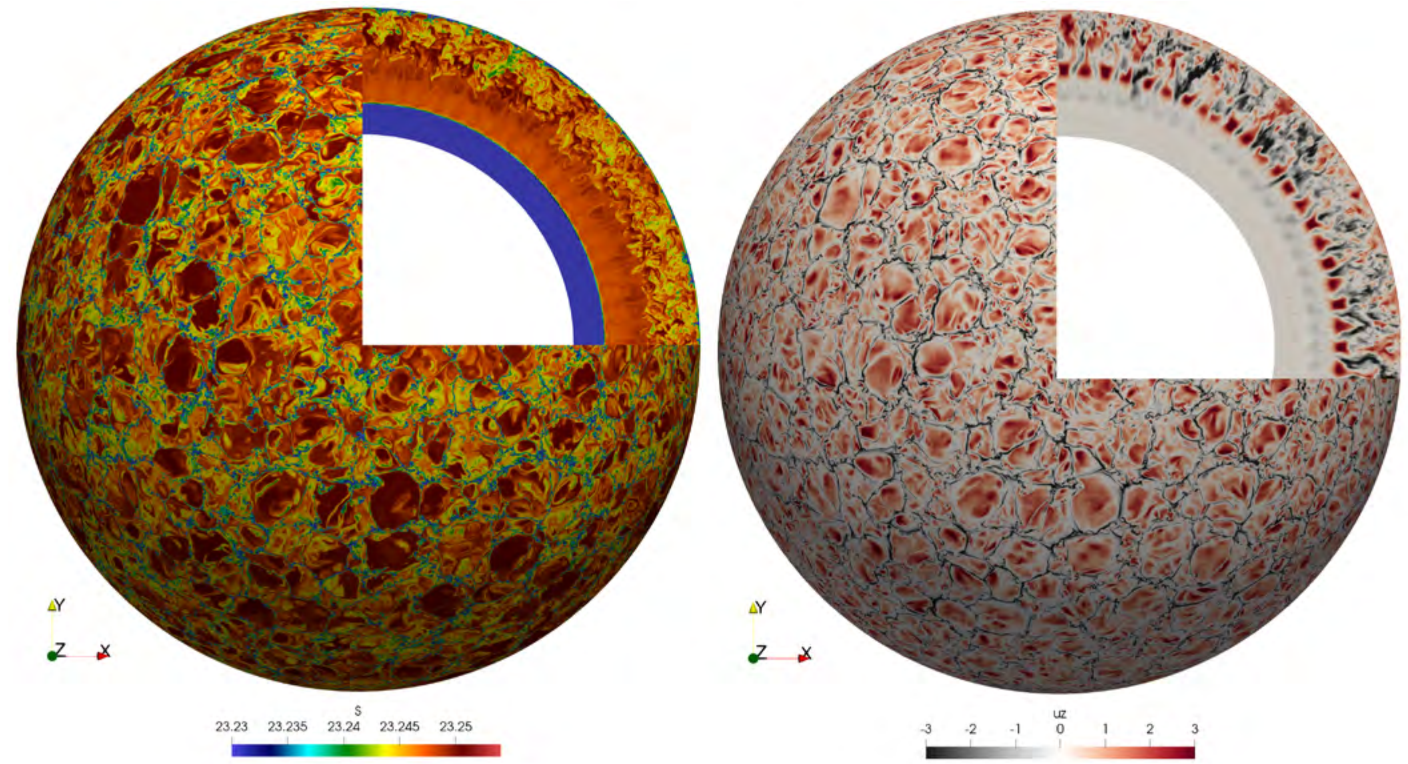


Figure 1. Left: One layer of the ‘volleyball’ mesh. The back side is removed for clarity. Right: Radial cut of the volleyball layers. Adapted from Popovas et al., 2022



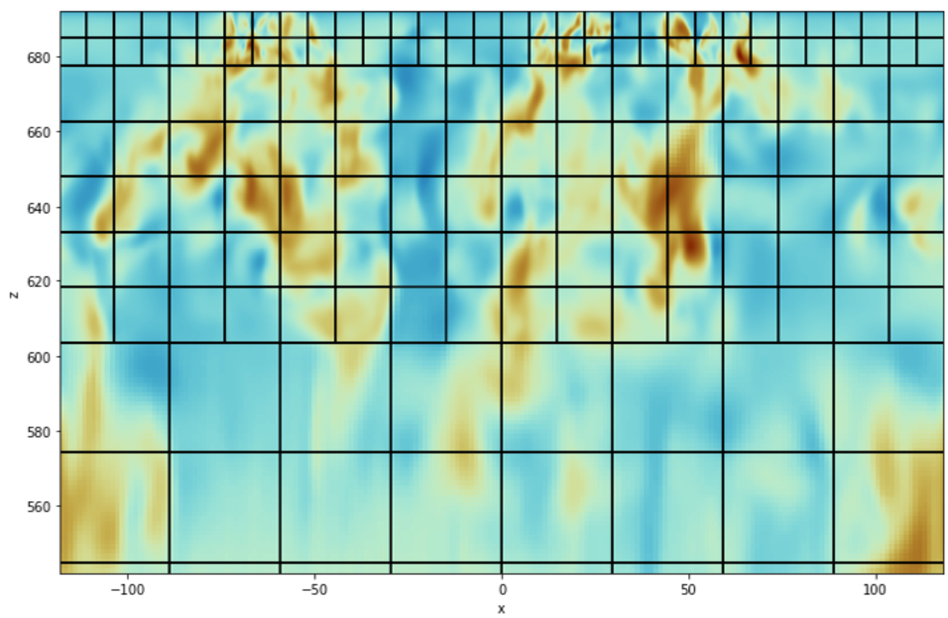


Figure 2. Left: Entropy per unit mass in the simulation, in code units. Right: Radial velocity in the simulation, in code units. In both panels the surface is 4.5 Megameters below the photosphere with cut-outs showing the radial structure. Adapted from Popovas et al., 2022

Figure 3. An example of mesh refinement close to the surface from a 'sandbox' version of the simulation. 2 additional levels are added, starting at 0.88 and 0.97 $R_{\odot}$. Adapted from Popovas et al., 2022

Supercomputers and perspectives

The relaxation runs were carried out on Norway's largest supercomputer Betzy as well as on the world's 3rd largest supercomputer; LUMI in Finland. On LUMI-C we ran the relaxation simulation using 96 nodes (each node contains 128 cores, so it total 12288 cores). With this size, in a 48 hour allocation period the relaxation simulation evolves 48.3 hours, so we can run in real Solar-time. The ideal allocation for the refined production run would be about 486 nodes (62208 cores).

Utilising a similar zoom-in technique (regridding / refining in space and time) as is commonly used in simulations of star formation, we will be able to use these simulations to, for example, model solar active region behaviour over a range of scales, without having to impose artificial initial and boundary conditions.

Andrius Popovas

Ongoing projects at RoCS in 2022

A number of externally funded projects exist as part of RoCS, in addition to the basic funding of RoCS from the Research Council of Norway and the University of Oslo.

ALMA Development Study "High cadence imaging of the Sun" (2019-2023), supported by ESO and RoCS, in cooperation with the Nordic ALMA Regional Center node at Onsala Space Observatory and Stockholm University, Sweden. Aim: Optimisation of solar observations with ALMA.

EMISSA ("Exploring Millimeter Indicators of Solar-Stellar Activity", 2019-2023), funded by the Research Council of Norway. Aim: Re-evaluation of stellar activity as observed with ALMA.

Hinode Science Data Centre Europe (2004-2025), funded by the European Space Agency through a contract with the Norwegian Space Agency and the European Union through the SOLARNET project. The data centre hosts all data from the Japanese Hinode and the NASA Interface Region Imaging Spectrograph (IRIS) solar satellites and a number of Bifrost simulations.

ISSRESS ("Impact of small-scale reconnection events on the solar atmosphere", 2021-2025), funded by the Research Council of Norway. Aim: To understand the origin and formation of small-scale magnetic reconnection events in the lower solar atmosphere and explore their role in the energy and mass transport from the lower to the upper solar atmosphere.

ORCS ("Oscillations in the Realistic Corona of the Sun", 2021-2025), funded by the Research Council of Norway. Aim: To combine the self-consistent numerical simulations of the solar atmosphere and high-resolution solar observations to understand the generation, evolution and dissipation of MHD oscillations in the structured and dynamical solar atmosphere.

Preparatory Phase of the European Solar Telescope (2017-2022), funded by the European Union Horizon's 2020 programme. The principal objective of the present Preparatory Phase is to provide both the EST international consortium and the funding agencies with a detailed plan regarding the implementation of EST.

SOLARNET (2019-2023), funded by the European Union's Horizon 2020 programme. The main objectives are to foster networking activities and mobility programmes, conduct joint research activities and ensure access to research infrastructures and databases in the field of high-resolution solar physics. There are 35 partners in 16 countries.

SOLDYN (2016-2023), funded by the Research Council of Norway and the University of Oslo. Aim: To advance our understanding of the complex dynamics of the solar atmosphere through the combination of high-quality observations from both ground-based and space-born instruments.

SPICE on Solar Orbiter (2016-2023), funded by the PRODEX programme. Finances the Norwegian contribution to the SPICE instrument on-board Solar Orbiter: The software that transforms the raw binary data from the remote-sensing instrument SPICE into a format that can be analyzed by scientists.

Whole Sun (2019-2026), funded by an ERC Synergy grant. How does the Sun work? Why does it possess a magnetic cycle, dark spots and a dynamic hot atmosphere? In the "Whole Sun" project, we aim at tackling these key questions as a coherent whole for the first time.

> In the Sun I feel as one
>
> Kurt Cobain

Credit: Daniel Nóbrega Siverio

Outreach

Outreach is a valued part of our work at RoCS, and we participate in a variety of activities in order to promote science education, knowledge and accessibility.

European Solar Telescope (EST)

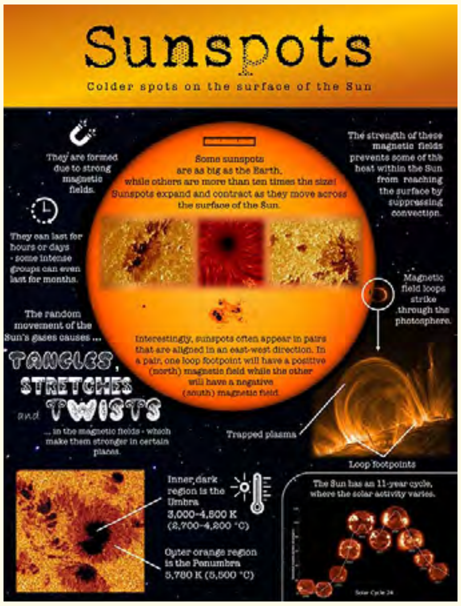
RoCS has been actively involved in the outreach program of the project PRE-EST (Preparatory Phase for EST). The project was financed by the European Union and had its end date on 30 September 2022. Some of the Outreach activities will continue with support from the Granada Institute in Spain.

RoCS is housed in Svein Rosseland's building. Rosseland was an internationally renowned Norwegian astrophysicist and founder of the Institute of Theoretical Astrophysics at the University of Oslo. An autumn photo of the building appeared in **The European Solar Telescope (EST) calendar** for November 2022.

The EST school competition "The Sun at a Glance" engaged 214 high schools in 16 different European countries. 171 students from Norway participated in the competition. A total of 561 European infographics were submitted. The infographics went into the comprehensive EST Solarpedia.

RoCS participated in the European Jury with Doctoral Research Fellow Aditi Bhatnagar and Communication Advisor Eyrun Thune. Assessing the entries was a long and difficult process. The jury selected three winners from Italy, Slovakia and Ireland. Two Norwegian teams came fourth and fifth.

The November photo of the EST Calendar: The Institute of Theoretical Astrophysics. Credit: Aditi Bhatnagar



One team from Asker upper secondary school made a particularly eye-catching and informative infographic at the EST school competition. It was voted fourth best entry. Credit: Screenshot of the infographic from RoCS' website.

Reetika Joshi standing in front of the Swedish 1 m Solar Telescope (SST) at La Palma (Canary Islands) for her first observational campaign in June-July 2022. Credit: Daniel Nóbrega Siverio

Women in Astrophysics Blog

Reetika Joshi, Postdoctoral Fellow, wrote the blog post "The Best Ph.D. Prize Award: Dedicated to all scientific collaborators" for "Women in Astrophysics" at Titan.uio.no. Titan is a digital newspaper for science and technology at the Faculty of Mathematics and Natural Sciences, University of Oslo.

Reetika describes her journey from becoming an astrophysicist to receiving a prize from The International Astronomical Union for the Best IAU Ph.D. Thesis Award in the Solar Physics division in 2021. She received her certificate at the 2022 IAU's General Assembly held in Busan, South Korea.

- The PhD-at-large prize 2021 has been an overwhelming experience for me. This award is not only mine, but I share this with all my scientific collaborators during my Ph.D. journey, says Reetika.

Astrophotography

Aditi Bhatnagar, Doctoral Research Fellow, became a board member of the Student Association - Universum Panton at UiO in 2022, where she is responsible for Astrophotography. Official name of the position is Photon. They organize observation trips a few weekends during the semester and take telescopes to Sognsvann. Many of her RoCS colleagues have become members and come to the trips.

The members of Universum Panton gathered at a spot at Sognsvann in October. Credit: Aditi Bhatnagar

Moon's picture taken on one of the observation nights. Credit: Aditi Bhatnagar

Open day

The University of Oslo (UiO) organizes annually a large trade fair for anyone interested in studies at UiO. **RoCS marketed solar physics studies with Mats Ola Sand, Doctoral Research Fellow, holding a 15 minute talk on the topic to a full auditorium with 200 people.**

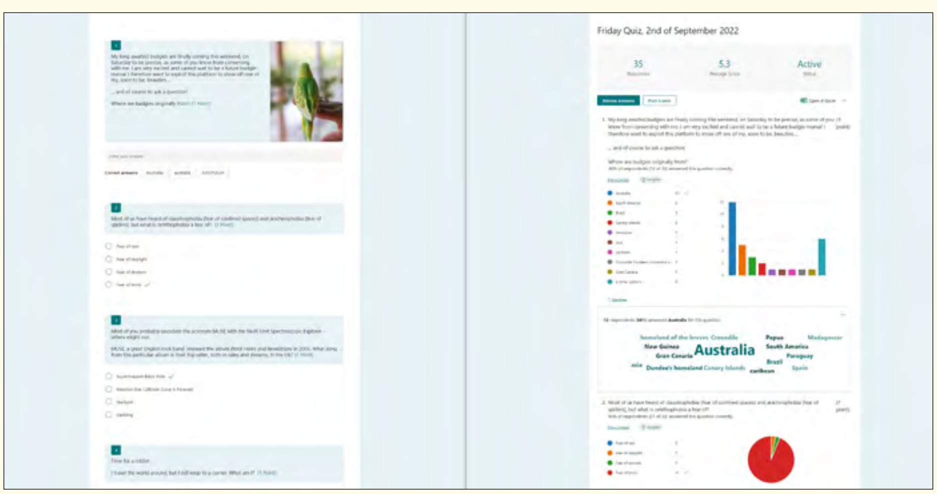
A photo of the Northern lights as seen from the International Space Station was included in the talk. Credit: Earth Science and Remote Sensing Unit, NASA Johnson Space Center. Image ISS029-E-6009 eol.jsc.nasa.gov

Friday's Quiz

- Most people, including myself, find it hard to get up for work on Fridays. We're tired and ready for the weekend. I therefore wanted to introduce a routine that everyone could look forward to when dragging themselves out of bed for the fifth day in a row, explains **Heidi Haugsand**. She stepped in as RoCS's coordinator for a year in August 2022 while Benedikte Fagerli Karlsen was on maternity leave. **The quiz is published Friday morning and everyone can participate in their own due** – during their first cup of coffee, a needed break or as the last thing done before the weekend begins.

- I knew that the quiz was a hit when I arrived late for work one Friday morning. At 9:15 AM the following question appeared in my inbox: "Will there be no quiz today?" **I understood how important social measures are for the work environment** and that small contributions do make a difference, says Heidi.

Popular quiz started by RoCS Coordinator Heidi Haugsand. Start date: 26th of August 2022. Number of participants: Approximately 35 contestants every week. Questions: Random things Heidi thinks about during the week.



RoCS and MUNCH's invitation to Researcher`s night, September 30th 2022, at the House of Literature in Oslo.

Researcher's Night

With the topic "**THE SUN: Art and Astrophysics meet**" people in Oslo had the opportunity to learn more about the Sun from two different perspectives on the last Friday in September 2022. **The European Researchers' Night is a Europe-wide public event**, which displays the diversity of science. **The event was supported by The Research Council of Norway** and was part of The National Science Week in Norway.

The introduction to the topic read: "Edvard Munch chose the Sun as the main motif in the decoration of the University's auditorium in Oslo. At the same university, we find some of the best solar researchers in the world today."

The two speakers: Sivert E. Iglebæk Thue from MUNCH and Oddbjørn Engvold from RoCS met and discussed the topic during some time and the two lectures fitted nicely together. They addressed questions such as: Why did Munch choose the Sun as his main motive, what was the most dramatic historical change in the understanding of the Sun and what do we know about the Sun today?

Sivert Thue, art mediator at MUNCH to the left and Oddbjørn Engvold, professor emeritus at the Rosseland Center for Solar Physics, Department of Theoretical Astrophysics, University of Oslo. The speaker's talked warmly about their research fields and got the audience engaged.
Credit: Private

School visits

Sondre Vik Furuseth, Postdoctoral Fellow, visited Sandvika High School, December 8th 2022. He talked to a Physics 2 class and their parents about higher education and **what physics can be used for.**

Ana Belen Grinon Marin, Postdoctoral Fellow, participated as a science fair judge at the Children's International School in Moss on May 24, 2022. **She also participated in a podcast** recorded by the children from the school on November 29, 2022.

Social media

RoCS has an active Twitter account, @RoCS_UiO, with 250 followers. RoCS also delivers content to social media at the Institute of Theoretical Astrophysics, UiO.

Astronomy Olympiad

Aditi Bhatnagar, Juan Camillo Guevara Gómez, Reetika Joshi, Sneha Pandit, Tiago Pereira, Avijeet Prasad, Luc Rouppe van der Voort, Mats Ola Sand and Eilif Sommer Øyre are part of the Astronomy Olympiad Team at ITA. The Norwegian Astronomy Olympiad is a competition for students at upper secondary schools with physics and astronomy as subjects. The top candidates represent Norway at the International Olympiad on Astronomy and Astrophysics.

Personal Outreach

"Pint of Science"

Mikolaj Szydlarski, Senior Engineer, held the talk "Understanding the Sun. Numerical models of our local star" in Oslo at the festival"Pint of Science" in Oslo 9-11. May 2022. The festival is a platform where one can discuss research with the people behind it. Szydlarski presented "the challenges and the importance of modern solar physics with particular attention to numerical simulations, which prove to be an invaluable tool to unlock the secrets of our host star".

"Solar Orbiter - a close-up look at the Sun"

Terje Fredvik, Senior Engineer, held two talks about the space probe Solar Orbiter:

- Open annual meeting of the Norwegian Astronomical Society 15th of October 2022
- Member meeting, Deep Sky Exploration 11th of October 2022

Expedition Lecturer at the Norwegian Coastal Express

Rebecca (Becca) Robinson, Doctoral Research Fellow, worked as an Expedition Lecturer on Hurtigruten Expeditions in the autumn of 2022. Becca did some of her "Outreach", which is a part of her Doctoral Research Fellow degree, on board the ship during 2021-22. Her lectures and workshops included:

- "A Sunny Day in the life of a solar physicist"
- "Northern Lights: An Origin Story"
- "Northern Lights: Can we really predict them?"
- "Why does the Sun Shine?"

Dumfries Astronomy Society

Lyndsay Fletcher, Adjunct Professor, gave a talk about "Solar Microscopes" 8th of March 2022 at the Dumfries Astronomy Society at Glasgow University.

Talk at "Orígenes"

Juan Camilo Guevara Gomez, Doctoral Research Fellow, held the talk "Revelando el ALMA del Sol: Observación de la cromósfera en el milimétrico" 26th of October 2022. The talk was aimed at bachelor students at the **Universidad de Antioquia in Colombia**. It was framed on the streamed program called "Orígenes", a biweekly space where researchers in astrophysics and with Colombian roots give a talk about their work to students pursuing the astronomy bachelor. The idea is to show them all the possible different fields within astronomy. The talks are usually at a technical level for bachelor students.

It can be an adrenalin kick to be a member of the staff at Hurtigruten. Science communicator at Hurtigruten: Rebecca Robinson, Doctoral Research Fellow at RoCS. Credit: Private

Junior Researcher

Doctoral Research Fellows Mats Ola Sand and Eilif Sommer Øyre along with Professor Sven Wedemeyer held a workshop in exoplanets during "Ungforsk 2022" at UiO. Ungforsk is a large science event aimed at secondary- and upper secondary school students. Sven Wedemeyer held an introduction to exoplanets before the students got to perform an experiment showcasing the transit method, which is an observational method for discovering exoplanets. Following this, the students explored the galaxy for known exoplanets using NASA's interactive web-app called "Exoplanet exploration". In this app, they discovered properties about exotic and neighbouring planetary systems. The students enjoyed the interactive nature of the workshop such as a Kahoot covering the learning goals at the end of the session. The scores were high; indicating the success of the format.

Mats Ola Sand, Eilif Sommer Øyre and Sven Wedemeyer held the 45 minutes long workshop for five groups over a two-day period, reaching about 100 students in total. Credit: Private

Media highlights

NRK Radio

Terje Fredvik, Senior Engineer, participated in the program "Abels bakgård" 2nd of September 2022 where Solar Activity and Solar Orbiter were amongst the topics.

Podcast "Universitetsplassen" (UiO)

Terje Fredvik talked about Solar Orbiter and the possibilities for Space Weather forecasts, that can warn about the knock out of power grids and communications, in March 2022.

Pål Brekke from The Norwegian Space Agency and Terje Fredvik from RoCS were guests at the Podcast "Universitetsplassen". Credit: UiO.

Astronomi

"Solar Orbiter see the magnetic field take a u-turn" (4/2022)

Titan

"The researchers observe the sun in extreme detail" (29.06.22)

"Kavli prize 2022 honors Stellar insights" (07.09.22)

Forskning.no

"Norwegian scientists will create spacecraft for NASA." (17.09.22)

Vårt Oslo

"Loredana went on a Northern Lights hunt to Sognsvann." (19.01.22)

Aftenposten

"Two legends tower over modern science. Both were met with resistance."(29.03.22)

"The Sun has "turned". This is how much more daylight you get every day"(21.12.22)

Unike bilder av sola

Sola har aldri vært «skarpere»

Dette bildet, tatt fra en romsonde midt mellom jorda og sola, er det mest høyoppløselige som er tatt av hele sola. Nå håper forskerne i det delvis norske prosjektet å finne svaret på en av solas største gåter.

UNIKT: «Bildene er de mest høyoppløselige noen gang som viser hele sola», opplyser RoCS-direktør Mats Carlsson. Foto: ESA & NASA/Solar Orbiter/EUI team; Data processing: E. Kraaikamp (ROB)

Screenshot of the article about the unique photos of the Sun in Dagbladet 26 March 2022.

Dagbladet

"Unique photos of the Sun. The Sun has never been brighter." (26.03.22)

Apollon

"NASA gets help from UiO researchers" (05.09.22)

Credit: Aditi Bhatnagar

International Rosseland Visitor Programme

Visits from internationally leading scientists are very important for the success of RoCS. The International Rosseland Visitor Programme is our programme for international exchange, including funds for visits by researchers at professor, post-doctoral and PhD level for shorter or longer visits to RoCS.

After two years of Covid and very few visitors, the visitor programme was finally moving towards normality in 2022.

RoCS arranged a weeklong workshop on 3D radiative transfer, in particular the code Multi-3D and how to port that code to the Dispatch framework. **Richard Hoppe** and **Philip Eitner** from the Max Planck Institute for Astronomy, Heidelberg, participated in person with **Maria Bergemann** from the same institute and **Jorrit Leenaarts** from the Institute for Solar Physics, Stockholm, participating online.

The operations team for the SPICE instrument onboard the Solar Orbiter satellite had a two-day meeting with 17 participants in Oslo in June.

Michaela Brchnelova from KU Leuven worked with Mats Carlsson on radiation hydrodynamics for one and a half months in March-April.

Philippa Browning from the University of Manchester visited in April.

Hugh Hudson from the University of Glasgow visited for two weeks in May.

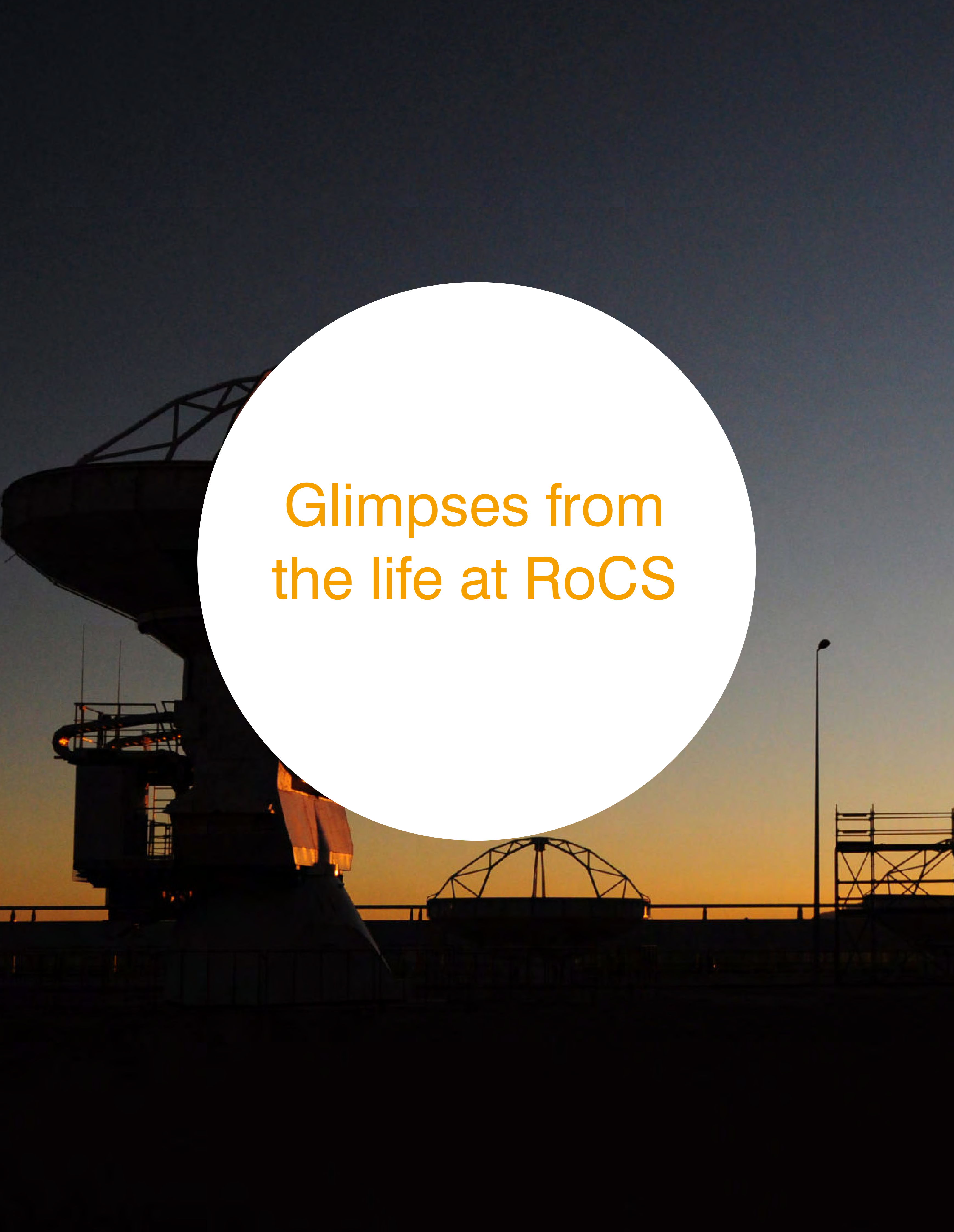
Jaime de la Cruz Rodriguez and **Carlos José Díaz Baso** from the Institute for Solar Physics, Stockholm University visited in June.

Sargam Mulay from the University of Glasgow worked with Mats Carlsson on radiation hydrodynamics and flare modelling for two weeks in October.

Paola Testa, researcher at the Smithsonian Astrophysical Observatory, visited in October to work with Luc Rouppe van der Voort, Mats Carlsson and other members of RoCS on several projects.

Diego Prado Barroso from the Brazilian National Institute for Space Research started a three month visit in December to work with Shahin Jafarzadeh and Luc Rouppe van der Voort on waves in the atmosphere of a sunspot.

Glimpses from the life at RoCS



Maintenance technicians, two antennas and a man lift. © ALMA (ESO/NAOJ/NRAO)

Social life at RoCS

Work and free time hand in hand; the possibilities are endless after a day's work at RoCS.


81

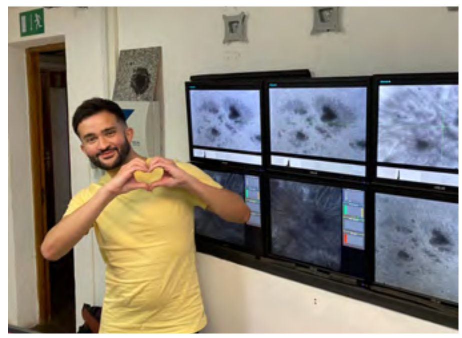

DINOS

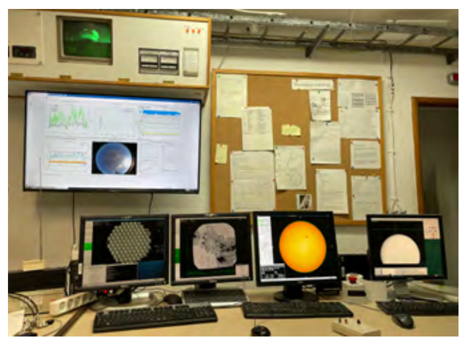

JA til ulv i norsk natur
STOPP SELFANGSTEN
MAKE HUMMUS NOT WAR
NOT WAR


STAR WARS

Life at the SST

After two years of COVID restrictions, we were finally back to La Palma in full capacity.





Taken from the University of Oslo (UiO). Credit: Aditi Bhatnagar

Optical phenomena of the Sun and clouds

Polar Stratospheric clouds, also known as Mother of Pearl clouds or Nacreous clouds, are formed in the stratosphere, as the name suggests. Nacreous comes from the word “nacrum”, which is latin for “mother of pearl”. This is used to describe their iridescent appearance. They are composed of tiny ice crystals, and the sunlight diffracts and refracts through them and thereby it creates the beautiful colors of the clouds. They play a role in the destruction of the ozone by facilitating chemical reactions that lead to the formation of ozone-depleting substances, which then participate in the catalytic destruction of ozone in the stratosphere.

Aditi Bhatnagar

Taken from the University of Oslo (UiO). Credit: Aditi Bhatnagar

Taken from Aditi Bhatnagar's home in Oslo. Credit: Aditi Bhatnagar

Sun halos

Sun halos form when sunlight passes through tiny ice crystals found in high-altitude cirrus clouds, which are located around 6 km or higher above us. These clouds appear as thin, wispy, white clouds. The light is refracted and reflected in different directions, creating a beautiful ring of light around the sun. Also, a little light is reflected towards the interior of the halo, giving it the impression of a "hole in the sky".

Sun pillars

Sun pillars are caused by the reflection of sunlight of millions of small hexagonal plate-like ice crystals that are suspended in the atmosphere, creating an elongated column of light. These are seen during sunrise and sunset.

Taken from Aditi Bhatnagar's home in Oslo. Credit: Aditi Bhatnagar

Taken next to The University Library, Georg Sverdrup's hus, UiO.
Credit: Aditi Bhatnagar

The future is bright

The number of masters students within Solar Physics has increased with RoCS becoming a Centre of Excellence. There are many reasons to choose this discipline and the choice can be made both with the heart and the head. We asked some of the first-year students.

Why Solar Physics?

Tor-Andreas Stensaker Bjone

- Solar physics can help solve practical problems related to energy, climate change and space technology. It is also exciting to work with data from space probes and telescopes.

Jonas R. Thrane

- I discovered Solar Physics in the Bachelor. We had to simulate a 2D star- atmosphere, which I think was a lot of fun.

Edvarda Harnes

- I found that I liked the theme through experiences from subjects on the Bachelor's course and the summer job I had at RoCS before starting the master's.

Stian Aannerud

- I liked that the field was more down-to-earth than the alternatives. In addition, I found RoCS attractive, with large numerical simulations and nice people.

What do you like best?

Tor-Andreas Stensaker Bjone

- The opportunity to dive deeper into the Sun phenomena and understand how it affects the earth and the solar system. I also enjoy being part of a large international research community.

Christophe Blomsen

- The social bit!

Jonas R. Thrane

- It's been fun exploring the simulations I've been assigned.

Edvarda Harnes

- When I immerse myself in the subject during a large project; I get to explore new opportunities and be a little creative.

Stian Aannerud

- I like that there is a great focus on numerical calculations. We also do project work where you can use the knowledge you have gained to solve a larger problem.

What are your future plans?

Tor-Andreas Stensaker Bjone

- I would like to contribute to an increased understanding of the Sun. Be it the development of new technologies which utilize solar energy in a more efficient way, or the development of space technology to study the sun.

Christophe Blomsen

- Hopefully I have enough energy for a PhD.

Jonas R. Thrane

- To find a job related to Physics or programming so I can use the knowledge I have acquired through my studies.

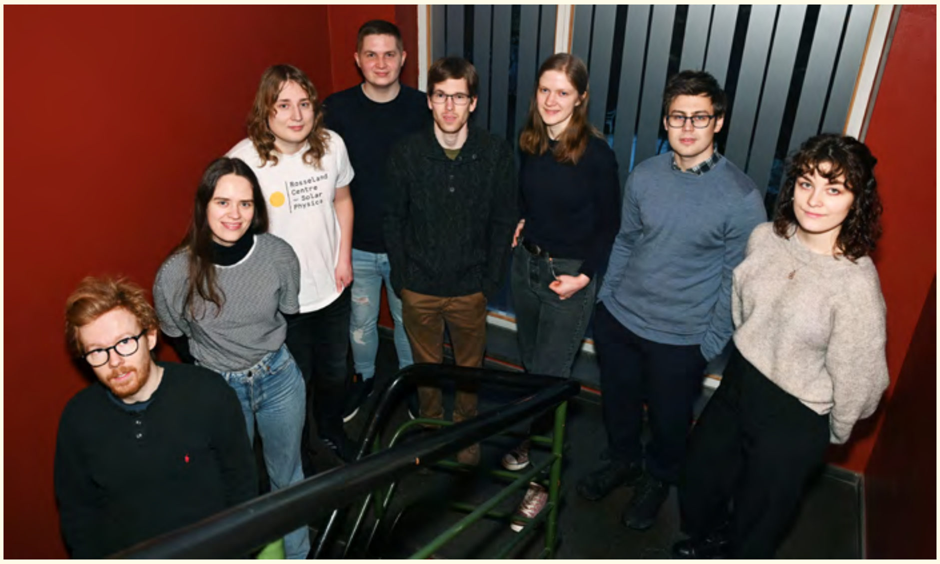
Edvarda Harnes

- I would like to do a PhD in something related to solar physics.

Stian Aannerud

- So far I'm unsure. It could be fun to continue with doctoral studies, but going out to work will also be fine.

Eyrun Thune



From left to right: Tor-Andreas S. Bjone, Aline Brunvoll, Mats Kirkaune, Stian Aannerud, Jonas Ringdalen Thrane, Edvarda Harnes, Christophe K. Blomsen and Semya A. Tønnesen. Eloi Martaille was not present. Credit: Ola Gamst Sæther

The award winner at the Besseggen ridge in Jotunheimen. Photo: Private

Prestigious prize awarded to Petra Kohutova

RoCS' researcher Petra Kohutova received the award for "important contributions to the understanding of thermal instability in the solar atmosphere, combining observations, theory, and modelling."

The Giancarlo Noci Early Career Prize is given by the European Solar Physics Division of the European Physical Society. The object of the Society is to contribute and promote the advancement of physics in Europe.

The ESPD Prize Committee was strongly impressed by Kohutova's background, by the high quality level of her research and publications. The official award of the Prize will take place during the next ESPD Meeting in 2024.

Not an easy task

- I'm very grateful to the European Solar Physics Division for the recognition of my research. It's taken years of hard work, on top of all the challenges well known to postdocs on short-term contracts, who do most of the research these days. This includes uprooting your life to move across the world every few years. I haven't been walking this path alone, so I want to give a shout-out to all my collaborators and people who were supportive and encouraging over the course of my career so far, says Kohutova.

Questions raised and answered

A large part of her research has been focused on answering the questions:

Does it rain on the Sun? Why? And why should we care?

- To do this, I have been combining numerical modelling (which tells us how we would expect our Sun to behave) and solar observations (which tell us how the Sun really behaves). Studying the formation of this 'plasma rain' gives us insight into how the solar atmosphere is heated. It also helps us to trace the magnetic field in the corona, because the rain droplets follow magnetic field lines as they fall. All of this ultimately contributes to improving our predictions of solar activity and its impacts on the Earth, Kohutova concludes.

Eyrun Thune

Northern lights in Oslo

The pictures of the Aurora Borealis were captured at Sognsvann, Oslo. A lake easily reached from the University of Oslo. From the beginning of autumn to the end of winter, RoCS' Doctoral Research Fellow, Aditi Bhatnagar enjoys the Northern Light hunt.

The Kp-index describes the disturbance of the Earth's magnetic field caused by solar wind. The faster the solar wind blows, the greater the turbulence. The index ranges from 0 to 9.

Photos: Aditi Bhatnagar

Kp index = 5

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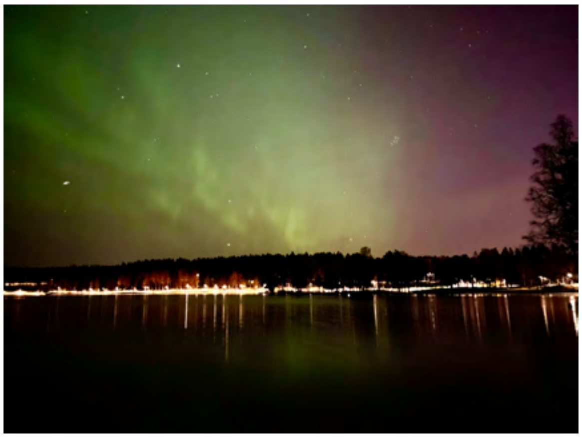

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Credit: Daniel Nóbrega Siverio

And the award goes to … Reetika Joshi and Souvik Bose

RoCS celebrated two international PhD prize winners in 2022. Both prize winners are from India and are part of the international solar physics community at RoCS in Oslo.

The prestigious PhD prizes were awarded in 2021 by the International Astronomical Union (IAU). The prize winners received their prizes in 2022 during the opening ceremony of the IAU General Assembly in Busan, South Korea.

Remarkable achievements

The IAU PhD Prize rewards astronomy PhD students. Each of the IAU's nine divisions gives a prize to the candidate that has carried out the most remarkable work in the previous year. The divisions also agree on the joint award, the PhD at-large Prize. 120 PhD theses were submitted to the 2021 prize awards.

The PhD at-large Prize

- To receive the IAU award in Busan was a dream, says Reetika. She received The PhD at-large Prize 2021 for her "Study of Solar Jets and Related Flares".

- This award is not only mine, I share this with all my scientific collaborators during my Ph.D. journey, Reetika underlines. She talks about her Ph.D.journey. From its start to its successful end. She developed a love of astrophysics during her masters and became passionate about it during her doctorate. - I have been very lucky to have the best mentors, in India and France, who showed me the way, she says. Reetika completed her Ph.D. in Solar Physics in November 2021 at Kumaun University, Nainital, India.

- My Ph.D. journey was very smooth. I travelled different countries for the research projects and realized that true happiness comes from learning together through interactions.

Reetika has a postdoctoral position at RoCS where she has been since February 2022. She is mainly working on the solar observations from the ground based Swedish 1 m Solar Telescope where she is involved in the research project "Whole Sun: Untangling the complex physical mechanisms behind our eruptive magnetic star and its twins".

It is indeed very satisfying that what I did, with the help of the excellent faculty at RoCS, means something.

Souvik Bose

The "Sun and Heliosphere" PhD Prize

Souvik Bose received the best PhD Prize 2021 within the division "Sun and Heliosphere" for his thesis "On the Dynamics of Spicules and Mass-Flows in the Solar Atmosphere".

Souvik completed his doctoral studies at RoCS in 2021 and is an affiliated researcher at RoCS. He focuses mainly on the dynamics of the solar atmosphere, in particular the origin and the evolution of spicules in the solar chromosphere. His main affiliation is with the Lockheed Martin Solar and Astrophysics Laboratory (LMSAL).

- Personally, this feels like a fantastic achievement. It is a culmination of an intensive four-year effort day in and day out, says Souvik. An award from such a prestigious organisation means that your work is recognised for its brilliance not just in your field but in astronomy in general.

- It is indeed very satisfying that what I did, with the help of the excellent faculty at RoCS, means something.

Eyrun Thune

IAU General Secretary Jose Miguel Rodriguez Espinosa presented the IAU PhD prize during the opening ceremony of the IAU General Assembly in Busan South Korea. Credit: IAU/GA2022 NOC.

Background IAU

The IAU, founded in 1919, is the world's largest professional body for astronomers and astrophysicists. It consists of more than 13.000 active professional astronomers from around 120 countries. It also serves as the internationally recognised authority for assigning designations to celestial bodies and the surface features on them.

Members of the centre


Credit: Aditi Bhatnagar

Members of the centre

The main resource of RoCS and its most important contributor is our staff. Everyone at our centre, scientific, administrative and technical, is handpicked because of their excellent qualifications and expertise. During 2022 we had 12 master students, 18 doctoral research fellows, fifteen postdocs and researchers, three research software engineers, two associate professors, four professors, one centre coordinator and one communication adviser. In addition, we had seven adjunct professors, as well as seven associated members in the administrative and technical staff, and five emiriti. Our Scientific Advisory Committee consisted of four members. Owing to our privileged position as a centre of excellence, we are able to grow in numbers, hiring talented and exceptional researchers of a large number of nationalities (currently 21 nationalities from four continents). All our members are putting their best efforts into strengthening our scientific achievements, setting forward new goals and reaching even higher standards for our research.

Phd

Helle Bakke

Helle Bakke is a doctoral research fellow at RoCS. Helle is at the interface between observations and numerical models, where she focuses on the effect of accelerated particles on the solar atmosphere. In particular, her research involves comparing synthetic observables to actual observations of low-energy events in the solar atmosphere.

Aditi Bhatnagar

Aditi Bhatnagar is a doctoral research fellow at RoCS. She studies the origin and impact of small-scale energetic phenomena in the solar atmosphere, mainly Ellerman Bombs in the quiet Sun (QSEBs). By combining observations from the lower atmosphere with IRIS observations from the higher layers, a more complete view of the impact of QSEBs on the solar atmosphere can be obtained. These results will further serve as valuable input for modeling efforts that are needed to achieve an understanding of their formation. She is also active in outreach activities, aurora chasing and enjoys communicating science to the public.

George Cherry

George Cherry is a doctoral research fellow at RoCS. They are a member of the CompSci PhD programme, which contributes intensive training in computational and data science. From this, they shall research new computational techniques to be developed within the Bifrost and Dispatch frameworks.

Phd

Frederik Clemmensen

Frederik Clemmensen was a doctoral research fellow at RoCS until 2022. The primary topic of Frederik's research was the processes in the solar atmosphere that lead to highly energetic, accelerated particles. For this purpose, he used new methods of numerical modelling which he was involved in developing. In general, Frederik is interested in programming and developments in computing.

Elisabeth Enerhaug

Elisabeth Enerhaug is a doctoral research fellow at RoCS. She is in her second year of a joint PhD between the University of St Andrews and the University of Oslo. She will be looking at MHD waves and coronal heating using numerical simulations and analysis.

Jonas Thoen Faber

Jonas Thoen Faber is a doctoral research fellow at RoCS where he also just finished his master thesis. He will continue to use observations from multiple instruments and analyze the data to draw potential conclusions on the complex behavior from the atmosphere of the Sun. He will mainly look at energetic events, namely flares, which are visible throughout the electromagnetic spectrum. The magnetic field maps are also used to find its correlation with the high energetic events.

Lars Frogner

Lars Frogner is a doctoral research fellow at RoCS. His research is mainly concerned with numerical modelling of the solar atmosphere, in particular the origin, behavior and effect of accelerated particles. He is generally interested in a range of topics in software development, including numerical simulations and computer graphics.

Øystein Håvard Færder

Øystein Håvard Færder is a doctoral research fellow at RoCS. He is a part of the Whole Sun team, and his research is focused on numerical simulations. During his master's, he simulated magnetic activity in the Quiet Sun atmosphere, and now he is running numerical simulations with magnetic reconnection using different electrical resistivity models to compare these models' ability to reproduce results in good agreement with each other and with theoretical estimates.

Juan Camilo Guevara Gómez

Juan Camilo Guevara Gómez finished his doctoral thesis in 2022 at RoCS. He analyzed solar observations with ALMA seeking for signatures of heating. Mainly doing tracking of small-scale features associated either to shock waves or MHD modes. Juan was also supporting his observational analysis by comparing the results with available simulations. Finally, Juan was also enrolled in outreach activities and he was the principal Team Leader of the Norwegian team for the International Olympiad on Astronomy and Astrophysics.

Phd

Michael Haahr

Michael Haahr is a doctoral research fellow at RoCS. He is part of the newly formed 'particle group' that tries to understand how particle acceleration occurs in the solar atmosphere. As a tool for this he is working on a new particle-in-cell (PIC) code to model the internals of solar flares. His main interests lie in simulations, numerical modelling and high performance computing.

Kilian Krikova

Kilian Krikova is a doctoral research fellow at RoCS. His PhD research is focused on studying the impact and origin of small-scale energetic phenomena in the lower solar atmosphere. His work is especially focused on Ellerman "bombs"(EB) which could play a significant role in heating the lower solar atmosphere and the reconfiguration of photospheric magnetic fields. Therefore he will combine state-of-the-art observations, simulations, and radiative transfer tools to get a better understanding of small-scale energetic phenomena at the Sun.

Thore Espedal Moe

Thore Espedal Moe is a doctoral research fellow at RoCS. His focus is on the formation of polarized spectral lines in the chromosphere. Taking a forward-modeling approach using numerical radiative transfer codes for synthesizing polarized spectra from the output of Bifrost simulations, he aims to better understand how and where these lines are formed, and how they can be used to diagnose magnetic phenomena.

Sneha Pandit

Sneha Pandit is a doctoral research fellow at RoCS. Sneha is analysing observational data taken by ALMA and comparing them with other observations. She studies the Sun in order to understand the structures of stars in general by combining state-of-the-art simulations, and radiative transfer tools. The 'Sun as a star approach' uses solar observations to estimate properties or features of other stars in order to understand the Sun and stars better. She wants to learn more about the solar-stellar observations and different techniques of data analysis and simulations. She enjoys outreach activities.

Ignasi Poquet

Ignasi Poquet is a doctoral research fellow at RoCS. He is a member of the CompSci PhD programme, which contributes intensive training in computational and data science. The main goal of his thesis is to understand the formation of small-scale events of magnetic reconnection in the solar atmosphere. For this purpose, the plan is to find and classify them by exploring large observational datasets. Ignasi will apply Deep Learning techniques to detect these events automatically. He will make use of solar observations from both ground-based and space-borne telescopes such as the SST and IRIS. Ignasi will also apply unsupervised learning techniques to detect anomalies in these solar observations.

Rebecca Robinson

Rebecca Robinson is a doctoral research fellow at RoCS. Rebecca is using simulations to explore quiet Sun magnetic fields and how they contribute to coronal heating. She likes to travel, teach, play music, go bouldering, eat waffles, drink coffee, and explore new places and ideas. She is enjoying her position with RoCS and is looking forward to contributing even more.

Phd

Mats Ola Sand

Mats Ola Sand is a doctoral research fellow at RoCS. His research project focuses on the origin of jets in the solar atmosphere; these jets are commonly referred to as spicules on smaller scales, and surges on larger scales. The project will compare these jets on different scales by studying high quality observations from ground-based and space-borne telescopes. In particular the connection between Ellerman Bombs in the quiet Sun (QSEBs) and spicules, and whether the reconnection in QSEBs could be the driver of some of the spicules observed all over the Sun.

Elias Roland Udnæs

Elias Roland Udnæs is a doctoral research fellow at RoCS. In his research project, Elias will combine high-resolution observations, magnetohydrodynamic (MHD) simulations, and machine learning techniques to identify and quantify heating mechanisms in the solar chromosphere. He hopes that his time at RoCS will lead to a tool that, with innovative methods, associates complex spectral data from current and future solar telescopes with heating signatures.

Eilif Sommer Øyre

Eilif Sommer Øyre is a doctoral research fellow at RoCS. Eilif will use simulations to study how particles are accelerated in the solar corona. In particular, he is developing a trace-particle code to follow particles embedded in realistic MHD-simulations of the solar atmosphere. This will provide the opportunity to better understand the physical processes at play in solar flare kernels. In general, Eilif is interested in numerical analysis and high performance computing, as well as rock climbing and the outdoors.

Postdocs and researchers

Souvik Bose

Souvik Bose is an affiliated researcher at RoCS. He completed his PhD at RoCS in 2021. Souvik's research mainly focuses on the dynamics of the solar atmosphere, in particular the origin and the evolution of spicules in the solar chromosphere. His main affiliation is with Lockheed Martin Solar and Astrophysics Laboratory (LMSAL).

Carlos José Díaz Baso

Carlos José Díaz Baso is a postdoctoral research fellow at RoCS. His general areas of interest are Bayesian statistics, deep learning, and solar physics. His research focuses on understanding solar chromospheric phenomena (from quiet solar filaments to explosive events) and their magnetic origin. He plans to achieve this goal by investigating high-quality space and ground-based spectropolarimetric observations with novel deep learning and Bayesian inference techniques, and comparing them with numerical models of the solar atmosphere.

Sondre Vik Furuseth

Sondre Vik Furuseth is a postdoctoral research fellow at RoCS. He did his PhD in accelerator physics at CERN, where he simulated the whole LHC beam. Now, he will work towards simulating the whole Sun. In particular, he is interested in simulating and understanding the physics of active regions, magnetic reconnection, and acceleration of particles.

Postdocs and researchers

Ana Belén Griñón-Marín

Ana Belén Griñón-Marín is a postdoctoral research fellow at RoCS. Her research is mostly focused on the long-term evolution of active regions. In particular she has studied the evolution over several days of the magnetic field topology in the solar photosphere of active regions of type alpha. Another important field of research for Ana concerns the study of light bridges by means of ground-based telescopes and space-borne missions. Her current interest aims at the characterization of light bridges through the whole solar atmosphere, from the photosphere to the corona.

Shahin Jafarzadeh

Shahin Jafarzadeh is an affiliated researcher at RoCS. Since September 2021, he is primarily employed by the Max Planck Institute for Solar System Research, Germany. He is predominantly interested in characterisation of wave activity in the lower solar atmosphere, and he is a founding member of the WaLSA international science team. He is also engaged in the science activities of the Solar Orbiter and of the SUNRISE balloon-borne solar observatory. Shahin is an experienced observer, particularly with SST, and passionately engages in public outreach activities.

Reetika Joshi

Reetika Joshi is a postdoctoral research fellow at RoCS. Her research area is focused on the multi-wavelength study of solar jets with ground based telescopes and space-borne satellites. Currently she is working on the imaging and spectroscopy analysis of solar jets and surges with the NASA's IRIS instrument and SST observations.

Chandrashekhar Kalugodu

Chandrashekar Kalugodu is a postdoctoral research fellow at RoCS. His research interests are understanding small-scale transient events in the solar atmosphere, observational magnetohydrodynamics, and superflares on stars and the Sun, and solar-stellar connection. His current focus is to study the coronal bright point(CBP) oscillations, chromospheric dynamics, and oscillations of the CBPs, using space-borne and ground based solar telescopes.

Petra Kohutova

Petra Kohutova is a researcher at RoCS. She is the PI of the RCN-funded ORCS project focusing on oscillations in realistic models of the solar atmosphere. She combines high resolution solar observations and numerical simulations.

Atul Mohan

Atul Mohan is a postdoctoral research fellow at RoCS. He studies the physics of frequent weak emissions omnipresent in the solar atmosphere analysing big datasets from modern radio telescopes. He works for the EMISSA project to understand the nature of atmospheric activity in different types of stars, including our Sun, using data from modern radio telescopes, mainly ALMA. The radio observations will be supplemented by high energy data and atmospheric models to understand the structure and dynamics of stellar atmospheres. The study will compare and contrast the Sun against similar stars.

Postdocs and researchers

Nancy Narang

Nancy Narang left RoCS in December 2022 after working as a postdoctoral researcher. Her new position is at the Royal Observatory of Belgium.

Quentin Noraz

Quentin Noraz is a postdoctoral research fellow at RoCS, contributing to the WholeSun ERC project. His areas of interest are dynamics and magnetism of the Sun and solar-type stars. During his PhD, he studied the impact of rotation and metallicity on the dynamo process and wind of solar-type stars, by using global numerical models. The main objectives will now be to investigate the solar wind formation mechanisms, to bring new magnetic constraints through the coupling of local and global MHD models, and to start going toward local simulations of stellar atmospheres.

Nicolas Poirier

Nicolas Poirier is a postdoctoral research fellow at RoCS, contributing to the ORCS project. During his Phd he contributed to the first analysis of the white-light observations from Parker Solar Probe using advanced forward modeling techniques and to the development of a novel multi-species model of the solar atmosphere to better understand the FIP effect. He plans now to bring his expertise to the ongoing RoCS projects, and specifically to the ORCS project where he will study wave properties in coronal loops using novel observatories (Solar Orbiter, DKIST) and post-processing methods.

Daniel Nóbrega Siverio

Daniel Nóbrega Siverio is an affiliated researcher at RoCS. He used to be a postdoctoral researcher, but he now works at Instituto de Astrofísica de Canarias (IAC) in Tenerife.

Avijeet Prasad

Avijeet Prasad is a postdoctoral research fellow at RoCS and part of the Whole Sun project team. Avijeet's research has mainly been focused on coronal magnetic field extrapolations derived from photospheric vector magnetograms and data-constrained magnetohydrodynamics simulations of high-energetic events in the solar corona like solar-flares and coronal mass ejections.

Maryam Saberi

Maryam Saberi is a postdoctoral research fellow at the ALMA RoCS group. She is mainly interested in studying solar and stellar chromospheric activity, aiming to understand the coronal heating problem. She is also interested in studying the role of strong UV photons from stellar activity on the chemical composition of evolved stars. She mainly uses observational data at mm/sub-mm wavelengths observed with the ALMA and APEX telescopes. She is also experienced in radiative transfer and chemical modelling of the outflow around evolved stars.

Research Software Engineers

Maria Guadalupe Barrios Sazo

Maria Guadalupe Barrios Sazo works as a research software engineer at RoCS. Her interests involve numerical methods for astrophysical simulations, high performance computing, and developing code in a sustainable manner. She looks forward to contributing to our understanding of the Sun through advanced computational techniques and state of the art supercomputers.

Andrius Popovas

Andrius Popovas works as a Research Software Engineer at RoCS. He works with developing next generation global magnetohydrodynamic simulations of the convective regions of the Sun and other stars. It will enable running experiments on an unprecedented scale and complexity, bridging the internal dynamo simulations to the surface of the Sun and stars on a global scale. These simulations will be run on the world's largest supercomputers.

Mikolaj Szydlarski

Mikolaj Szydlarski works as a research software engineer at RoCS. Physicist and Mathematician by education, but Computer Scientist by heart. Mikolaj is interested in the application of high-performance computing (HPC) to challenging problems in solar astrophysics. His fields of expertise include MHD simulations and Solar ALMA data reduction.

Adjunct professors

Guillaume Aulanier

Guillaume Aulanier is an Adjunct Professor at RoCS. He develops 3D numerical models coupled with multi-wavelength observations for solar flares, prominences, and reconnection. He is an expert in magnetic field topology, and is the original developer of the MHD code OHM. He is a member of the science teams of SDO and Solar Orbiter. His home institution is the Laboratory for Plasma Physics in Paris. He is deputy-director of the astrophysics graduate school of Université Paris Science & Lettres, chair of the Sun-Earth national programme of CNRS, and policy officer for HPC at the ministry of research.

Ineke De Moortel

Ineke De Moortel is an Adjunct Professor at RoCS. Her research focuses on coronal heating, in particular the efficiency of heating by MHD waves, using a combination of numerical simulations and observational data analysis. Her home institute is the University of St Andrews (UK). From September 2021, one of her PhD students, Elisabeth Enerhaug, has started a joint PhD between the Universities of St Andrews and Oslo.

Bart De Pontieu

Bart De Pontieu is an Adjunct Professor at RoCS. His research is aimed at understanding how the Sun's magnetic field energizes the coupled solar atmosphere from the photosphere into the corona and heliosphere. He focuses on combining high resolution space-based and ground-based multi-wavelength observations with advanced numerical modeling. He is the PI of NASA's IRIS and MUSE satellite projects and manages the IRIS/MUSE research team at Lockheed Martin Solar & Astrophysics Laboratory (LMSAL) in Palo Alto, California, USA. He is also the institutional PI of the JAXA/NASA EUVST project at LMSAL.

Adjunct professors

Lyndsay Fletcher

Lyndsay Fletcher is an Adjunct Professor at RoCS. Her main research interest is solar flares, specifically the transport of energy through the flare atmosphere, the energisation of the chromosphere and the interpretation of radiation signatures to help us understand this process. She works mostly on data analysis, figuring out ways to confront data with flare models. As well as research, she teaches astrophysics to students at all levels in her home institute (University of Glasgow, UK) and leads efforts to increase the fraction of women and girls participating in physics and astronomy.

Juan Martínez-Sykora

Juan Martínez-Sykora is an Adjunct Associate Professor at RoCS and based at LMSAL and BAERI. He is deputy science lead of MUSE (NASA MIDEX program selected for Phase B and to be launched in 2027) and EUVST Co-I. His major contributions are on numerical modeling of the solar atmosphere. His main interests focus on chromospheric heating and dynamics and multi-fluids using and developing state of the art 3D radiative MHD codes and comparing the models with ground based and space observations.

Åke Nordlund

Åke Nordlund is an adjunct professor at RoCS. Nordlund works at the Astrophysics and Planetary Sciences group at the Niels Bohr Institute and STARPLAN at University of Copenhagen. He is a member of the Niels Bohr International Academy, the Norwegian Academy of Sciences and Letters, and the Royal Swedish Academy of Science.

Marianne G. Omang

Marianne Gjestvold Omang is an Adjunct Associate Professor at RoCS. She works for the Norwegian Defence Estate Agency in the R&D section. Her field of interest is shock and blast waves, looking at spontaneous shock ignition of reactive particles. The numerical multi-phase code RSPH (Regularized Smoothed Particle Hydrodynamics) is used for the numerical simulations. The experimental work is performed, using both shock tubes and high explosives. Visualization techniques such as Schlieren and Shadowgraph are used to study the shock and blast wave phenomena in closer detail.

> In every person there is a sun. Just let them shine.

Socrates

Principal investigators

Mats Carlsson

Mats Carlsson is a professor and the director of RoCS. Main interests include chromospheric physics and radiation MHD. He is working with both large-scale simulations and observations from the ground and from space.

Boris Gudiksen

Boris Gudiksen is a professor and PI at RoCS with focus on the development of numerical codes used to run simulations of the solar atmosphere. His main interest is the solar corona and how it maintains its high temperature.

Viggo Hansteen

Viggo Hansteen is a senior researcher at Bay Area Environmental Research Institute as well as being a part time professor and PI at RoCS. He works both on simulations and observations, from the ground and from space. He is interested in how the magnetic field is formed in the deep convection zone, how it rises to the photosphere, and how it forms the outer solar atmosphere. Flux emergence, coronal heating and chromospheric dynamics and energetics are keywords.

Tiago M. D. Pereira

Tiago M. D. Pereira is an associate professor and PI at RoCS. He studies dynamic processes in stellar atmospheres. In particular, he is working on the solar chromosphere, the interface between the hot corona and the dense surface. Tiago leverages space and ground-based observations with detailed radiative transfer calculations from 3D models. With an interest in computational astrophysics, data analysis and visualization, he works with high-performance computing and big data problems.

Luc Rouppe van der Voort

Luc Rouppe van der Voort is a professor and PI at RoCS. Luc's main area of research is high-resolution observations of the Sun. He is a veteran observer at the Swedish 1-m Solar Telescope on the island of La Palma. For many years, he has been running coordinated observing campaigns with the SST and space-borne telescopes, such as IRIS and Hinode, and earlier TRACE and SOHO.

Sven Wedemeyer

Sven Wedemeyer is a professor and PI at RoCS. Sven leads the research activities related to solar and stellar observations with ALMA and supporting simulations, which in 2022 included the EMISSA project (RCN), and an ESO-funded ALMA development study. His research mostly focuses on the small-structure, dynamics and energy balance of the solar atmosphere with implications for other stellar types.

Centre administration

Benedikte Fagerli Karlsen

Benedikte Fagerli Karlsen is the centre coordinator at RoCS. She is on maternity leave from October 2022. She is responsible for the administration of the centre and takes care of all practical tasks related to the centre's activity. Among her tasks are new employment, visitors, contracts, reporting and logistics at events.

Heidi Haugsand

Heidi Haugsand is working as a temporary centre coordinator at RoCS from August 2022 to August 2023.

Eyrun Thune

Eyrun Thune is a communication adviser at RoCS. She is responsible for communication and outreach activities at RoCS.

Technical and administrative associated staff

Martina D'Angelo

Martina D'Angelo works as a communication advisor and press contact at the Institute of Theoretical Astrophysics (ITA). Martina's main responsibilities are science communication, outreach activities, and promotion on social media channels. She is the web editor for ITA website and coordinator for the Norwegian Olympiad on Astronomy and Astrophysics.

Terje Fredvik

Terje Fredvik is an engineer in the institute's Project Related IT Services (PRITS) group. He is the lead of the development of the data pipeline for the Solar Orbiter SPICE instrument. He is also a contributor to the operations of the Hinode Science Data Centre Europe, a member of the ITA FITS Working Group, and assists in the adaptation of the SOLARNET2 FITS mechanisms for both observational and simulated data.

Stein Vidar Hagfors Haugan

Stein Vidar Haugan is the technical lead for the Project Related IT Services (PRITS) group. He is responsible for the Hinode Science Data Centre Europe, serving data from the Hinode and IRIS missions and from SPICE on Solar Orbiter. He is the lead for the ITA FITS Working Group, acts as a liaison between RoCS and the SOLARNET2 project, and contributes to the data pipeline and quicklook software for Solar Orbiter SPICE.

Technical and administrative associated staff

Kristine Aa. S. Knudsen

Kristine Aa. S. Knudsen is the Head of Office at the Institute of Theoretical Astrophysics. She is the head of our administration, and cooperates closely with both the scientific, technical and administrative staff at RoCS and the Institute.

Torben Leifsen

Torben Leifsen is the head of IT at the institute. He is responsible for planning, building and running the IT systems together with the IT-group at the institute. A second server room was added in 2020 to accommodate the needs of RoCS and other projects. Torben has a background in solar physics and is a member of the Virgo team on the ESA spacecraft SOHO, and is doing research in helioseismology in his spare time.

Wojciech Olejarz

Wojciech Olejarz works in the Project Related IT Services group as a front-end developer on the new Hinode archive front end. He has a very broad background within IT, with a large skill set and a natural flair for programming.

Martin Wiesmann

Martin Wiesmann is an engineer in the institute's Project Related IT Services (PRITS) Group. He is responsible for part of the IRIS pipeline as well as the adaptation of AIA and Hinode data to IRIS data. Martin also contributes to the Solar Orbiter SPICE pipeline and quicklook software. He is mainly a programmer, implementing requests and wishes from various scientists into the pipeline or as separate programs.

Scientific Advisory Committee

Tony Arber

Tony Arber is a computational plasma physicist whose interests span solar physics, space weather, laser-plasmas and QED-plasmas. He has been responsible for developing MHD codes for both solar physics and laser-driven fusion as well as kinetic codes for high-power plasma interactions. For all codes, he is interested in software development methods and uncertainty quantification.

Sarah Matthews

Sarah Matthews is a Professor of Solar Physics at UCL's Mullard Space Science Laboratory. Her research interests focus on energy storage and release in magnetised plasmas, and in particular solar eruptive events and space weather. Her work is mainly observational, bringing together multi-wavelength space and ground-based observations, but she also works in collaboration with magnetic field modellers in particular to interpret the observations in the context of current models. She also has an interest in instrumentation and is currently the Hinode EIS PI.

Oskar Steiner

Oskar Steiner is a senior researcher at the Leibniz-Institut für Sonnenphysik (KIS) in Freiburg, Germany and at the Istituto Ricerche Solari Locarno (IRSOL) in Switzerland. His research focuses on the numerical simulation of magnetohydrodynamic processes in the solar and stellar atmospheres. He is also interested in polarimetry and numerical methods of radiative transfer.

Francesca Zuccarello

Francesca Zuccarello is an associate professor at the University of Catania (Italy). Francesca is involved in the study of emergence, evolution and decay of solar active regions, as well as in research related to solar eruptive events. Francesca is mainly an observer. She participated in several Coordinated Observational Campaigns.

Emiriti

Oddbjørn Engvold

Oddbjørn Engvold is an emeritus professor at RoCS. One of his main areas of research is the structure and dynamics of solar prominences. He is a veteran user of the Swedish 1-m Solar Telescope on the island of La Palma, of solar telescopes of the US National Solar Observatory (NSO) and solar telescopes in space. He has in recent years edited and contributed to two books related to solar activity.

Olav Kjeldseth-Moe

Olav Kjeldseth-Moe is an emeritus professor at RoCS. His area of special interest is the transition region into the corona and over the years he has contributed to the development of instruments and observing procedures designed to map conditions in this part of the solar atmosphere. Thus, he participated in the small group of daily science planners at NASAs Skylab Observatory in 1973-74, was a co-investigator on the HRTS instrument on Spacelab 2 in 1985, and finally served for 20 years as the Norwegian co-investigator for the CDS spectrometer on SOHO.

Egil Leer

Egil Leer is an emeritus professor at RoCS. His main areas of interest include the corona, the solar wind, and the interaction of the solar wind with the local interstellar medium.

Rob Rutten

Rob Rutten was an emeritus adjunct professor at RoCS. Rutten passed away at the age of 80 in September 2022. Rob was a well-respected scientist with a long and productive career in high-resolution solar physics. He was a leading expert in radiative transfer and spectral diagnostics. His lecture notes are used in teaching radiative transfer worldwide.

Jan Trulsen

Jan Trulsen is an emeritus professor at RoCS. His main areas of research includes plasma physics, turbulence phenomena in ionized and neutral media, numerical simulations.

Master students

Isak Aaby

Isak was a master student at RoCS until March 2022.

Stian Aannerud

Stian is a second-year master student at RoCS. In his thesis he will study the effect of the Hall term on magnetic reconnection, by implementing a module in the Bifrost MHD simulation. He started his project in spring 2022 with Boris Gudiksen as his supervisor.

Tor-Andreas S. Bjone

Tor-Andreas S. Bjone is a first-year master student at RoCS. In his thesis he will create a 3D MHD model of the CZ to explore supergranulations and effects between the magnetic field and plasma. He will start his work in autumn 2023 under the supervision of B. Gudiksen and S.V. Furuseth.

Christophe K. Blomsen

Christophe K. Blomsen is a first-year master student at RoCS. In his thesis he will study non-LTE radiative transfer, using GPU. He started on his thesis autumn 2022 under the supervision of Tiago M. D. Pereira.

Aline R. Brunvoll

Aline R. Brunvoll is a first-year master student at RoCS. Under supervision of Luc Rouppe van der Voort she will compare high-resolution Hα and Hβ observations from the SST, aiming to learn how recent observations from the CHROMIS instrument can advance our understanding of the solar chromosphere.

Edvarda Harnes

Edvarda is a second-year master student at RoCS. She works on applying physics-informed neural networks for the computation of non-LTE radiative transfer, and the goal is to synthesise spectral lines from a 3D model atmosphere. She started the work on her thesis in the autumn of 2022 under the supervision of Tiago M. D. Pereira.

Master students

Mats Kirkaune

Mats is a second-year master student at RoCS. His thesis is on searching for stellar emission in the sub-THz bands, where he looks for stellar emission at mm/radio wavelengths in archival observations. He started the work on his thesis in autumn 2022 under the supervision of Atul Mohan and Sven Wedemeyer.

Ilse Kuperus

Ilse Kuperus finished her master studies at RoCS in 2022.

Eloi Martaille

Eloi Martaille is a first-year master student at RoCS.

Jonas Ringdalen Thrane

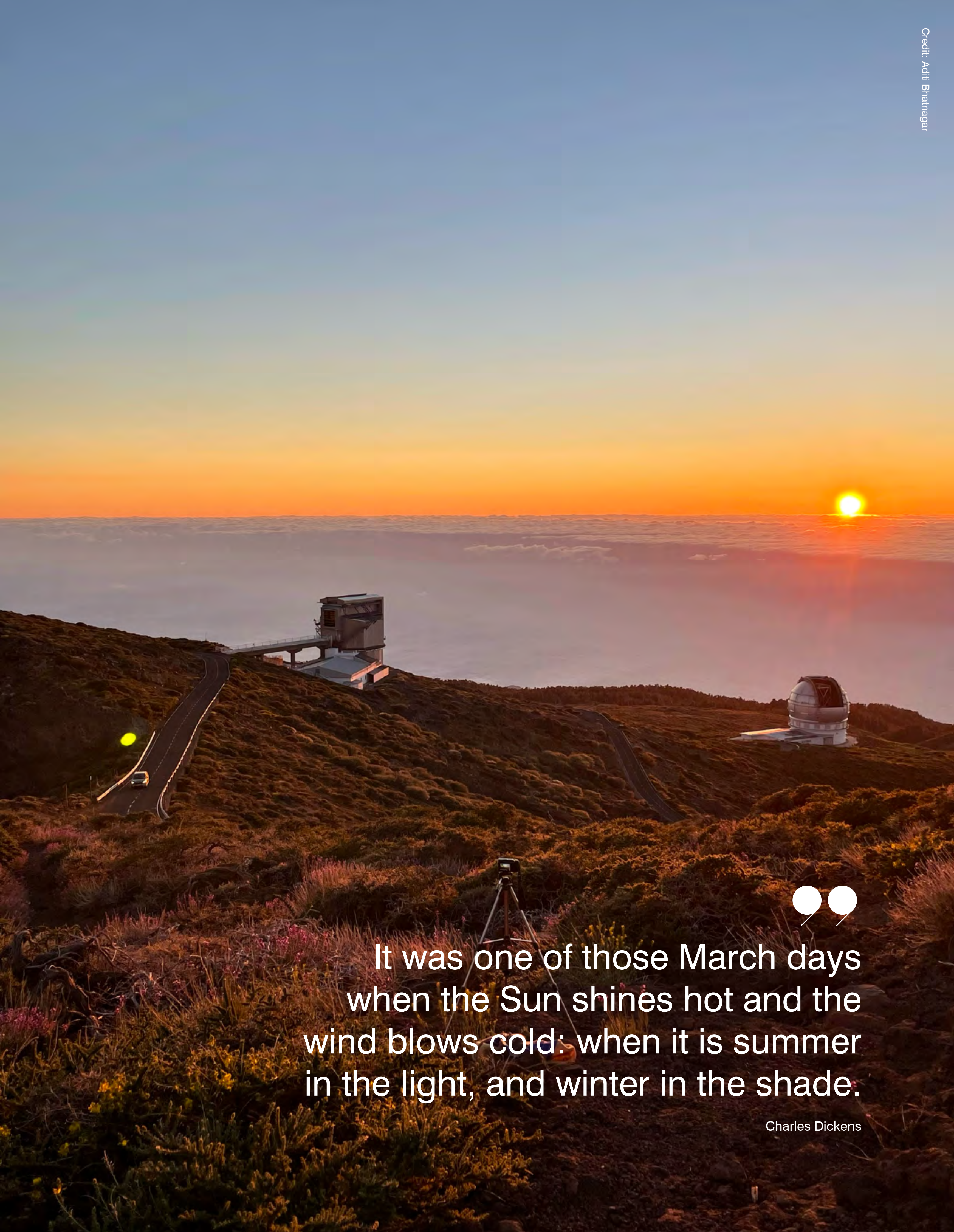
Jonas is a second-year master student at RoCS. In his thesis he will perform artificial observations of different stellar types at millimetre wavelengths, using a new sequence of state-of-the-art 3D numerical simulations of stellar atmospheres. The resulting data will facilitate studying the diagnostic potential of millimetre observations of other stars. He started his thesis in the autumn of 2022 under the supervision of Sven Wedemeyer.

Semya Amouche Tønnessen

Semya A. Tønnessen is a first-year master student at RoCS. The working title of the master project is “Making sense of the solar chromosphere – investigations of the diagnostic power of various spectral lines” with Mats Carlsson as supervisor.

Marte Cecilie Wegger

Marte finished her master studies at RoCS in 2022.



Credit: Aditi Bhatnagar

> It was one of those March days when the Sun shines hot and the wind blows cold: when it is summer in the light, and winter in the shade.
>
> Charles Dickens

Talks and presentations 2022

Aulanier, Guillaume. Prominences and CME precursors: Why sheared arcades have to be considered. SHINE workshop 2022; 2022-06-27 - 2022-07-01

Carlsson, Mats. Solar atmospheric modelling and diagnostics. NBIA workshop on Radiation Transfer in Astrophysics; 2022-06-06 - 2022-06-10

Carlsson, Mats. Understanding the workings of the energetic Sun. dScience seminar; 2022-10-13

Díaz Baso, Carlos José. Unlocking the potential of deep learning for the analysis of spectropolarimetric observations. Solar Polarization Workshop 10 (SPW10); 2022-11- 07 - 2022-11-11

Fletcher, Lyndsay. Living with a Star. University of the 3rd Age; 2022-01-12

Fletcher, Lyndsay. Solar Microscopes. Dumfries Astronomy Society; 2022-03-08

Frogner, Lars. Accelerated particle beams in a 3D simulation of the quiet Sun. 10th Coronal Loops Workshop; 2022-06-28 - 2022-07-01

Færder, Øystein Håvard. Simulating reconnection in the Solar Corona with different resistivity models. Whole Sun Gathering 2022; 2022-03-07 - 2022-03-25

Grinon Marin, Ana Belen. A new view into flaring sunspots. Solar Polarization Workshop 10; 2022-11-07 - 2022-11-11

Grinon Marin, Ana Belen. A new view into flaring sunspots. European Astronomical Society Annual Meeting; 2022-06-26 - 2022-07-01

Guadalupe Barrios Sazo, Maria; Observations meet simulations at Rosseland Center of Solar Physics. Astrovisualization, The role of images in Astronomy and Space sciences; 2022-06-02 - 2022-06-03

Guevara Gomez, Juan Camilo. Revelando el ALMA del Sol: observación de la cromósfera en el milimétrico. ORÍGENES; 2022-10-26

Guevara Gomez, Juan Camilo; Jafarzadeh, Shahin; Wedemeyer, Sven. Characterisation of bright chromospheric and oscillating small-scale features observed with ALMA. 44th COSPAR Scientific Assembly; 2022-07-16 - 2022-07-24

Jafarzadeh, Shahin. High-resolution Wave Activity in the Lower Solar Atmosphere. The UK's National Astronomy Meeting (NAM) 2022; 2022-07-11 - 2022-07-15

Jafarzadeh, Shahin. The Sun and Solar Activity. The International Space Science School (ISSS) 2022; 2022-11-24 - 2022-11-26

Jafarzadeh, Shahin. Wave Studies in the Lower Solar Atmosphere with Solar Orbiter. XIII COLAGE (the Latin American Conference on Space Geophysics); 2022-11- 27 - 2022-12-03

Kohutova, Petra; Popovas, Andrius; Antolin, Patrick; **Szydlarski, Mikolaj; Carlsson, Mats.** Coronal oscillations in the self-consistent 3D MHD simulations of the solar atmosphere. Hinode-15/IRIS-12 meeting; 2022-09-19 - 2022-09-23

Kohutova, Petra; Popovas, Andrius; Antolin, Patrick; **Szydlarski, Mikolaj; Carlsson, Mats.** Coronal oscillations in the self-consistent 3D MHD simulations of the solar atmosphere. 44th COSPAR Scientific Assembly; 2022-07-16 - 2022- 07-24

Krikova, Kilian; Pereira, Tiago; Rouppe van der Voort, Luc. Diagnostic potential of H for small-scale energetic phenomena. IAUGA XXXI; 2022-08-01 - 2022-08-12

Krikova, Kilian; Pereira, Tiago; Rouppe van der Voort, Luc; Carlsson, Mats. Diagnostic potential of H for small-scale energetic phenomena. Hinode-15 / IRIS-12; 2022-09-19 - 2022-09-23

Martinez-Sykora, Juan. Modeling of small-scale phenomena. COSPAR assembly; 2022-06-11 - 2022-06-22

Martinez-Sykora, Juan. Multifluid Alfven wave simulations to understand the chemical fractionation in the chromosphere and the role of the NEQ ionization. COSPAR assembly; 2022-06-11 - 2022-06-22

Martinez-Sykora, Juan. New insights into the transition region from IRIS observations and numerical simulations that include non-equilibrium ionization. Hinode 15/IRIS 12; 2022-10-19 - 2022-10-23

Martinez-Sykora, Juan. RMHD simulations of the chromosphere with NEQ ionization and ion-neutral interaction effects. Rice University; 2022-09-23

Moe, Thore Espedal; Pereira, Tiago; Carlsson, Mats. Effects of spatial resolution on inferences of atmospheric quantities from simulations. Advances in Solar MHD Numerical Simulations in the Era of High-Resolution Observations; 2022-08-07 - 2022-08-10

Moe, Thore Espedal; Pereira, Tiago; Carlsson, Mats. Effects of spatial resolution on inferences of atmospheric quantities from simulations. Hinode-15 / IRIS-12; 2022-09-19 - 2022-09-23

Mohan, Atul. Novel insights and discoveries pertaining to weak solar activity with MWA. MWA project meeting 2022; 2022-12-07 - 2022-12-08

Mohan, Atul; Oberoi, Divya; **Wedemeyer, Sven;** Mondal, Surajit; McCauley, Patrick; Mastrano, Alpha; **Pandit, Sneha;** Hauschildt, Peter, H.; **Saberi, Maryam.** Tomographic exploration of solar/stellar activity with modern radio & mm arrays. Planetary, Solar, and Heliospheric Radio Emissions XI Conference; 2022-09-26 - 2022-09-28

Mohan, Atul; Wedemeyer, Sven; Hauschildt, Peter, H.; Pandit, Sneha; Saberi, Maryam. Stellar atmospheric tomography with mm - cm spectroscopic imaging. COSPAR 2022 conference; 2022-07-16 - 2022-07-24

Mohan, Atul; Wedemeyer, Sven; Oberoi, Divya; Hauschildt, Peter, H.; McCauley, Patrick; Mondal, Surajit; Mastrano, Alpha; **Pandit, Sneha; Saberi, Maryam.** New insights on solar/stellar activity using the tomographic potential of mm & radio spectroscopic imaging. Academic seminar; 2022-07-12

Mohan, Atul; Wedemeyer, Sven; Pandit, Sneha; Saberi, Maryam; Hauschildt, Peter. A potential robust millimeter activity index & its links to atmospheric structure and physical parameters. Cool stars 2022 meeting; 2022-07-04 - 2022-07-09

Nóbrega Siverio, Daniel. A 2D model for Coronal Bright Points: Association with spicules, UV bursts, surges, and EUV coronal jets. XV Reunión Científica de la SEA; 2022-09-07

Nóbrega Siverio, Daniel. Contribution title: Solar surges related to UV bursts: characterization through k-means, inversions, and density diagnostics. Hinode-15/IRIS-12; 2022-09-19

Nóbrega Siverio, Daniel. Simulations of flux emergence events. Centre for mathematical Plasma-Astrophysics (CmPA) seminars; 2022-06-09

Nóbrega Siverio, Daniel. Simulations of flux emergence events. International School of Space Science; 2022-04-14

Nóbrega Siverio, Daniel. Solar surges related to UV bursts: characterization through k-means, inversions, and density diagnostics. COSPAR-22. E2.4: The dynamic sun at small scales.; 2022-07-22

Noraz, Quentin. New insights about the past, present and future of solar magnetism. European Solar Physics Online Seminars; 2022-12-01

Pandit, Sneha; Wedemeyer, Sven; Mohan, Atul. Formation of Activity Indicators in a 3D model Atmosphere. COSPAR 2022; 2022-07-16 - 2022-07-24

Pandit, Sneha; Wedemeyer, Sven; Mohan, Atul. The Formation of Activity Indicators in 3D Model Atmosphere. IAUS 372; 2022-08-02 - 2022-08-05

Pandit, Sneha; Wedemeyer, Sven; Carlsson, Mats. Formation of Activity Indicators in a 3D Model Atmosphere. Cool Stars 21; 2022-07-04 - 2022-07-08

Pandit, Sneha; Wedemeyer, Sven; Mohan, Atul. Formation of Activity Indicators in a 3D model atmosphere. 50 years of Skumanich relations; 2022-03-08 - 2022-03-11

Pereira, Tiago. Speeding up 3D non-LTE spectral synthesis with neural networks. XXXIst General Assembly International Astronomical Union; 2022-08-02 - 2022-08-11

Pereira, Tiago. Speeding up 3D non-LTE spectral synthesis with neural networks. Hinode-15 / IRIS-12 meeting; 2022-09-19 - 2022-09-23

Poirier, Nicolas; Réville, Victor; Rouillard, Alexis; Kouloumvakos, Athanasios; Pinto, Rui F.; Griton, Léa. The (possible) origin of streamer blobs observed by PSP-WISPR. PSP-WISPR Consortium meeting; 2022-10-26

Popovas, Andrius; Szydlarski, Mikolaj; Nordlund, Åke. First results from global MHD simulations of Solar convective zone. Hinode-15/IRIS-12 meeting; 2022-09-17 - 2022-09-23

Popovas, Andrius; Szydlarski, Mikolaj; Nordlund, Åke. Multi-scale simulations of the Sun. Center for Space Science Workshop; 2022-10-10 - 2022-10-12

Prasad, Avijeet. A Global Galactic Dynamo with a Corona Constrained by Relative Helicity. Virtual Nordic Dynamo Seminar; 2022-08-30

Prasad, Avijeet. Inferring the magnetic topology of the inverse Evershed flow using non-force-free extrapolations. Seminar for the Astronomy & Astrophysics group, University of Glasgow; 2022-02-24

Prasad, Avijeet. MHD modelling of eruptive phenomena in the solar atmosphere. ISSI Bern team meeting on coronal dimming; 2022-09-19 - 2022-09-23

Robinson, Rebecca Anne. A Sunny Day in the life of a solar physicist. The Ultimate Winter Expedition Cruise from Dover; 2022-11-20 - 2022-12-08

Robinson, Rebecca Anne. Coherent Reconnection from a Tangled Mess. Hinode-15/IRIS-12; 2022-09-19 - 2022-09-23

Robinson, Rebecca Anne. Northern Lights: an Origin Story. The Ultimate Winter Expedition Cruise from Dover; 2022-11-20 - 2022-12-08

Robinson, Rebecca Anne. Northern Lights: can we really predict them? The Ultimate Winter Expedition Cruise from Dover; 2022-11-20 - 2022-12-08

Robinson, Rebecca Anne. Northern Lights: can we really predict them? Norway Winter Expedition Cruise from Dover; 2022-01-09 - 2022-03-06

Robinson, Rebecca Anne. Simulating convection-driven magnetic reconnection in 3D with Bifrost. 10th Coronal Loops Workshop 2022; 2022-06-28 - 2022-07-01

Robinson, Rebecca Anne. Why does the Sun Shine? (or: why I still have a job). Norway Winter Expedition Cruise from Dover; 2022-01-09 - 2022-03-06

Saberi, Maryam; Khouri, T.; Velilla-Prieto, L.; Fonfria, J. P.; Vlemmings, W.; **Wedemeyer, Sven.** Tracing the role of AGB stars in the Galactic Fluorine budget. Iranian National Observatory Conference; 2022-02-02 - 2022-02-03

Sand, Mats Ola. Et glimt fra solfysikken. Åpen dag ved UiO; 2022-03-10

Szydlarski, Mikolaj. Understanding the Sun. Numerical models of our local star. Pint of Science; 2022-02-07

Wedemeyer, Sven; Sand, Mats Ola; Øyre, Eilif Sommer; D`Angelo, Martina. På jakt etter eksoplaneter. Ungforsk; 2022-09-28 - 2022-09-29

Papers in refereed journals 2022

Antolin, Patrick; **Martínez-Sykora, Juan;** and Şahin, Seray: 2022, The Astrophysical Journal, 926, L29, Thermal Instability-Induced Fundamental Magnetic Field Strands in the Solar Corona

Bakke, H.; Carlsson, M.; Rouppe van der Voort, L.; Gudiksen, B. V.; Polito, V.; Testa, P.; and **De Pontieu, B.:** 2022, Astronomy and Astrophysics, 659, A186, Chromospheric emission from nanoflare heating in RADYN simulations

Bate, W.; Jess, D. B.; Nakariakov, V. M.; Grant, S. D. T.; **Jafarzadeh, S.**; Stangalini, M.; Keys, P. H.; Christian, D. J.; and Keenan, F. P.: 2022, The Astrophysical Journal, 930, 129, High-frequency Waves in Chromospheric Spicules

Bora, K.; Bhattacharyya, R.; **Prasad, Avijeet;** Joshi, Bhuwan; and Hu, Qiang: 2022, The Astrophysical Journal, 925, 197, Comparison of the Hall Magnetohydrodynamics and Magnetohydrodynamics Evolution of a Flaring Solar Active Region

Brooks, David H., et al. (30 authors, among them **Carlsson, Mats, Fredvik, Terje**): 2022, The Astrophysical Journal, 940, 66, Plasma Composition Measurements in an Active Region from Solar Orbiter/SPICE and Hinode/EIS

Chappell, Bruce A. and **Pereira, Tiago M. D.**: 2022, Astronomy and Astrophysics, 658, A182, SunnyNet: A neural network approach to 3D non-LTE radiative transfer

Cheung, Mark C. M., et al (28 authors, among them **Martínez-Sykora, Juan; De Pontieu, Bart; Fletcher, Lyndsay; Nóbrega-Siverio, Daniel; Hansteen, Viggo; Carlsson, Mats**): 2022, The Astrophysical Journal, 926, 53, Probing the Physics of the Solar Atmosphere with the Multi-slit Solar Explorer (MUSE). II. Flares and Eruptions

De Moortel, I. and Howson, T. A.: 2022, The Astrophysical Journal, 941, 85, (When) Can Wave Heating Balance Optically Thin Radiative Losses in the Corona?

De Oliveira e Silva, Alexandre José; Selhorst, Caius Lucius; Costa, Joaquim E. R.; Simões, Paulo J. A.; Giménez de Castro, Carlos Guillermo; **Wedemeyer, Sven**; White, Stephen M.; Brajša, Roman; Valio, Adriana, 2022, Frontiers in Astronomy and Space Sciences, 9, 1118

De Pontieu, Bart et al. (27 authors, among them **Martínez-Sykora, Juan; Hansteen, Viggo; De Moortel, Ineke; Nóbrega-Siverio, Daniel; Carlsson, Mats**): 2022, The Astrophysical Journal, 926, 52, Probing the Physics of the Solar Atmosphere with the Multi-slit Solar Explorer (MUSE). I. Coronal Heating

Devi, Pooja; Chandra, Ramesh; Awasthi, Arun Kumar; Schmieder, Brigitte; and **Joshi, Reetika**: 2022, Solar Physics, 297, 153, Extreme-Ultraviolet Wave and Accompanying Loop Oscillations

Druett, M. K.; Leenaarts, J.; **Carlsson, M.**; and **Szydlarski, M.**: 2022, Astronomy and Astrophysics, 665, A6, Formation and heating of chromospheric fibrils in a radiation-MHD simulation

Dudík, Jaroslav; **Aulanier, Guillaume**; Kašparová, Jana; Karlický, Marian; Zemanová, Alena; Lörinčík, Juraj; and Druckmüller, Miloslav: 2022, The Astrophysical Journal, 937, L10, Filament Leg-Leg Reconnection as a Source of Prominent Supra-arcade Downflows

Finley, A. J.; Brun, A. S.; **Carlsson, M.; Szydlarski, M.; Hansteen, V.**; and Shoda, M.: 2022, Astronomy and Astrophysics, 665, A118, Stirring the base of the solar wind: On heat transfer and vortex formation

Grant, S. D. T.; Jess, D. B.; Stangalini, M.; **Jafarzadeh, S.**; Fedun, V.; Verth, G.; Keys, P. H.; Rajaguru, S. P.; Uitenbroek, H.; MacBride, C. D.; Bate, W.; and Gilchrist-Millar, C. A.: 2022, The Astrophysical Journal, 938, 143, The Propagation of Coherent Waves Across Multiple Solar Magnetic Pores

Guevara Gómez, Juan Camilo; Jafarzadeh, Shahin; Wedemeyer, Sven; and Szydlarski, Mikolaj: 2022, Astronomy and Astrophysics, 665, L2, Propagation of transverse waves in the solar chromosphere probed at different heights with ALMA sub-bands

He, Wen; Hu, Qiang; Jiang, Chaowei; Qiu, Jiong; and **Prasad, Avijeet:** 2022, The Astrophysical Journal, 934, 103, Quantitative Characterization of Magnetic Flux Rope Properties for Two Solar Eruption Events

Henriques, Vasco M. J.; Jafarzadeh, Shahin; Guevara Gómez, Juan Camilo; Eklund, Henrik; Wedemeyer, Sven; Szydlarski, Mikołaj; Haugan, Stein Vidar H.; and **Mohan, Atul:** 2022, Astronomy and Astrophysics, 659, A31, The Solar ALMA Science Archive (SALSA). First release, SALAT, and FITS header standard

Hong, J.; **Carlsson, M.**; and Ding, M. D.: 2022, Astronomy and Astrophysics, 661, A77, An approximate recipe of chromospheric radiative losses for solar flares

Howson, T. A. and **De Moortel, I**.: 2022, Astronomy and Astrophysics, 661, A144, The effects of driving time scales on coronal heating in a stratified atmosphere

Hu, Qiang; Zhu, Chunming; He, Wen; Qiu, Jiong; Jian, Lan K.; and **Prasad, Avijeet:** 2022, The Astrophysical Journal, 934, 50, Validation and Interpretation of a Three-dimensional Configuration of a Magnetic Cloud Flux Rope

Hudson, Hugh S.; Mulay, Sargam M.; **Fletcher, Lyndsay;** Docherty, Jennifer; Fitzpatrick, Jimmy; Pike, Eleanor; Strong, Morven; Chamberlin, Phillip C.; and Woods, Thomas N.: 2022, Monthly Notices of the Royal Astronomical Society, 515, L84, Fast prograde coronal flows in solar active regions

Joshi, Jayant and Rouppe van der Voort, Luc H. M.: 2022, Astronomy and Astrophysics, 664, A72, Properties of ubiquitous magnetic reconnection events in the lower solar atmosphere

Joshi, Reetika; Mandrini, Cristina H.; Chandra, Ramesh; Schmieder, Brigitte; Cristiani, Germán D.; Mac Cormack, Cecilia; Démoulin, Pascal; and Cremades, Hebe: 2022, Solar Physics, 297, 81, Analysis of the Evolution of a Multi-Ribbon Flare and Failed Filament Eruption

Kowalski, Adam F.; Allred, Joel C.; **Carlsson, Mats;** Kerr, Graham S.; Tremblay, Pier-Emmanuel; Namekata, Kosuke; Kuridze, David; and Uitenbroek, Han: 2022, The Astrophysical Journal, 928, 190, The Atmospheric Response to High Nonthermal Electron-beam Fluxes in Solar Flares. II. Hydrogen-broadening Predictions for Solar Flare Observations with the Daniel K. Inouye Solar Telescope

Kumar, Sanjay; **Prasad, Avijeet;** Sarkar, Ranadeep; and Bhattacharyya, Ramit: 2022, Frontiers in Astronomy and Space Sciences, 9, 1039061, Magnetohydrodynamics evolution of three-dimensional magnetic null in NOAA active region 11515 initiated using non-force-free field extrapolation

Labrosse, Nicolas; Rodger, Andrew S.; Radziszewski, Krzysztof; Rudawy, Paweł; Antolin, Patrick; **Fletcher, Lyndsay;** Levens, Peter J.; Peat, Aaron W.; Schmieder, Brigitte; and Simões, Paulo J. A.: 2022, Monthly Notices of the Royal Astronomical Society, 513, L30, First high resolution interferometric observation of a solar prominence with ALMA

Ledvina, Vincent E.; Kazachenko, Maria D.; Criscuoli, Serena; Tilipman, Dennis; Ermolli, Ilaria; Falco, Mariachiara; Guglielmino, Salvatore; **Jafarzadeh, Shahin; Rouppe van der Voort, Luc;** and Zuccarello, Francesca: 2022, The Astrophysical Journal, 934, 38, Quantifying Properties of Photospheric Magnetic Cancellations in the Quiet Sun Internetwork

Leka, K. D.; Wagner, Eric L.; **Griñón-Marín, Ana Belén;** Bommier, Véronique; and Higgins, Richard E. L.: 2022, Solar Physics, 297, 146, Correction to: On Identifying and Mitigating Bias in Inferred Measurements for Solar Vector Magnetic-Field Data

Leka, K. D.; Wagner, Eric L.; **Griñón-Marín, Ana Belén;** Bommier, Véronique; and Higgins, Richard E. L.: 2022, Solar Physics, 297, 121, On Identifying and Mitigating Bias in Inferred Measurements for Solar Vector Magnetic-Field Data

Liu, Yang; **Griñón-Marín, Ana Belén;** Hoeksema, Jon T.; Norton, Aimee A.; and Sun, Xudong: 2022, Solar Physics, 297, 17, On the Hemispheric Bias Seen in Vector Magnetic Field Data

Lörinčík, Juraj; Polito, Vanessa; **De Pontieu, Bart;** Yu, Sijie; and Freij, Nabil: 2022, Frontiers in Astronomy and Space Sciences, 9, 1040945, Rapid variations of Si IV spectra in a flare observed by interface region imaging spectrograph at a sub-second cadence

Martínez Oliveros, Juan Carlos; **Guevara Gómez, Juan Camilo;** Saint-Hilaire, Pascal; Hudson, Hugh; and Krucker, Säm: 2022, The Astrophysical Journal, 936, 56, Observations of Thomson Scattering from a Loop-prominence System

Martínez-Sykora, Juan; Hansteen, Viggo H.; De Pontieu, Bart; and Landi, Enrico: 2022, The Astrophysical Journal, 938, 60, A Novel Inversion Method to Determine the Coronal Magnetic Field Including the Impact of Bound-Free Absorption

Mathur, Harsh; **Joshi, Jayant;** Nagaraju, K.; **Rouppe van der Voort, Luc;** and **Bose, Souvik:** 2022, Astronomy and Astrophysics, 668, A153, Properties of shock waves in the quiet-Sun chromosphere

Moe, Thore E.; Pereira, Tiago M. D.; and **Carlsson, Mats:** 2022, Astronomy and Astrophysics, 662, A80, Effects of spatial resolution on inferences of atmospheric quantities from simulations

Mohan, A.; Wedemeyer, S.; Hauschildt, P. H.; **Pandit, S.;** and **Saberi, M.**: 2022, Astronomy and Astrophysics, 664, L9, EMISSA (Exploring millimetre indicators of solar-stellar activity). II. Towards a robust indicator of stellar activity

Moreno-Insertis, F.; **Nóbrega-Siverio, D.**; Priest, E. R.; and Hood, A. W.: 2022, Astronomy and Astrophysics, 662, A42, Ambipolar diffusion: Self-similar solutions and MHD code testing. Cylindrical symmetry

Narang, Nancy; Chandrashekhar, Kalugodu; Jafarzadeh, Shahin; Fleck, Bernhard; **Szydlarski, Mikołaj;** and **Wedemeyer, Sven:** 2022, Astronomy and Astrophysics, 661, A95, Power distribution of oscillations in the atmosphere of a plage region. Joint observations with ALMA, IRIS, and SDO

Nindos, Alexander; Patsourakos, Spiros; **Jafarzadeh, Shahin;** and Shimojo, Masumi: 2022, Frontiers in Astronomy and Space Sciences, 9, 981205, The dynamic chromosphere at millimeter wavelengths

Nóbrega-Siverio, D. and Moreno-Insertis, F.: 2022, The Astrophysical Journal, 935, L21, A 2D Model for Coronal Bright Points: Association with Spicules, UV Bursts, Surges, and EUV Coronal Jets

Omang, M. and Hauge, K. O.: 2022, Shock Waves, 32, 691, Shock ignition of aluminium particle clouds in the low-temperature regime

Osborne, Christopher M. J. and **Fletcher, Lyndsay:** 2022, Monthly Notices of the Royal Astronomical Society, 516, 6066, Flare kernels may be smaller than you think: modelling the radiative response of chromospheric plasma adjacent to a solar flare

Panesar, Navdeep K.; Tiwari, Sanjiv K.; Moore, Ronald L.; Sterling, Alphonse C.; and **De Pontieu, Bart**: 2022, The Astrophysical Journal, 939, 25, Genesis and Coronal-jet-generating Eruption of a Solar Minifilament Captured by IRIS Slit-raster Spectra

Pascoe, D. J.; Van Doorsselaere, T.; and **De Moortel, I.**: 2022, The Astrophysical Journal, 929, 101, Coronal Seismology Using Damping of Propagating Kink Waves

Pascoe, D. J.; **De Moortel, I.**; Pagano, P.; and Howson, T. A.: 2022, Monthly Notices of the Royal Astronomical Society, 516, 2181, Propagating Alfv{\'e}n waves in open structures with random structuring

Peter, Hardi et al., (18 authors, among them **De Pontieu, Bart**): 2022, The Astrophysical Journal, 933, 153, Parallel Plasma Loops and the Energization of the Solar Corona

Prasad, A.; Ranganathan, M.; Beck, C.; Choudhary, D. P.; and Hu, Q.: 2022, Astronomy and Astrophysics, 662, A25, The magnetic topology of the inverse Evershed flow

Quintero Noda, C., et al. (281 authors, among them **Aulanier, G.; Carlsson, M.; Fletcher, L.; Hansteen, V.H.; Ortiz, A., Rouppe van der Voort, L.**;): 2022, Astronomy and Astrophysics, 666, A21, The European Solar Telescope

Rachmeler, L. A., et al. (28 authors, among them **De Pontieu, B.; Carlsson, M.**): 2022, The Astrophysical Journal, 936, 67, Quiet Sun Center to Limb Variation of the Linear Polarization Observed by CLASP2 Across the Mg II h and k Lines

Robinson, Rebecca A.; Carlsson, Mats; and **Aulanier, Guillaume:** 2022, Astronomy and Astrophysics, 668, A177, From incoherent field to coherent reconnection. Understanding convection-driven coronal heating in the quiet Sun

Ruiz Cobo, B.; **Quintero Noda, C.;** Gafeira, R.; Uitenbroek, H.; Orozco Suárez, D.; and Páez Mañá, E.: 2022, Astronomy and Astrophysics, 660, A37, DeSIRe: Departure coefficient aided Stokes Inversion based on Response functions

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Silva, Suzana S. A.; Murabito, Mariarita; **Jafarzadeh, Shahin**; Stangalini, Marco; Verth, Gary; Ballai, Istvan; and Fedun, Viktor: 2022, The Astrophysical Journal, 927, 146, The Importance of Horizontal Poynting Flux in the Solar Photosphere

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Stangalini, M.; Verth, G.; Fedun, V.; Aldhafeeri, A. A.; Jess, D. B.; **Jafarzadeh, S.**; Keys, P. H.; Fleck, B.; Terradas, J.; Murabito, M.; Ermolli, I.; Soler, R.; Giorgi, F.; and MacBride, C. D.: 2022, Nature Communications, 13, 479, Large scale coherent magnetohydrodynamic oscillations in a sunspot

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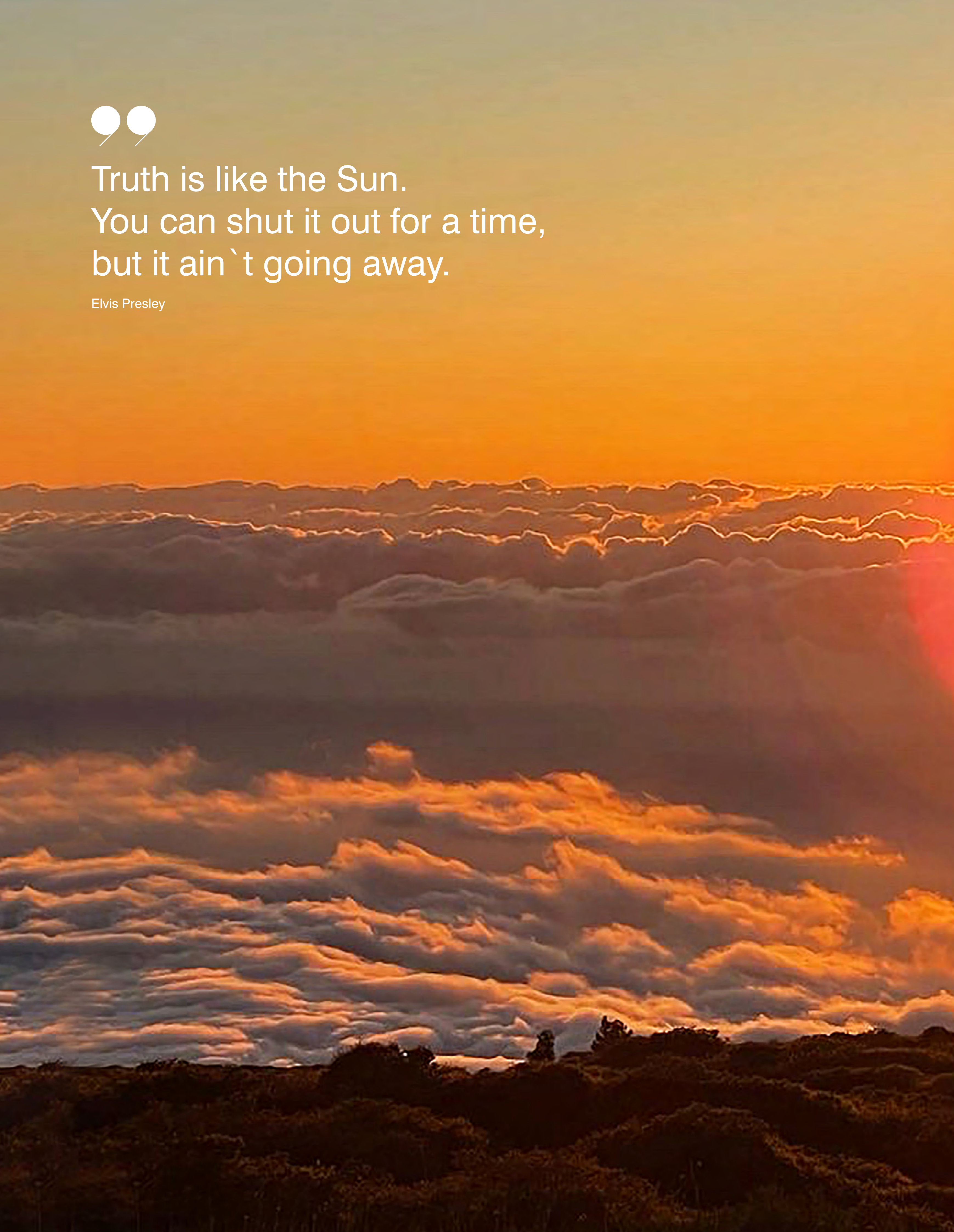
Truth is like the Sun.
You can shut it out for a time,
but it ain`t going away.

Elvis Presley



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