CMA IN BRIEF

FACTS AND FIGURES OF THE 2006 ACTIVITIES

In 2006, CMA counted 89 members (56.3 man years), among these:
- 19 senior scientists, 36 PhD-students, 18 postdocs, 13 adjunct positions, 1 scientific programmer, 1 project coordinator, and 1 administrative officer.
- 3 PhD-students finished their degrees in 2006.

CMA received:
- 13 long term international visitors (stays of more than one month), and 69 different international guests on short-time (less than one month) visits. These 83 international guests represent 20 different countries, and together they spent 6.5 man-years at CMA.
- Around 100 different Norwegian guests (short-time), many of them several times, participating in our events (workshops, conferences, and seminar series) or collaborating with our members.

Total revenues of 2006 were MNOK 43.1 (CoE funding: 11.0, UiO: 16.3, SINTEF: 2.4, Other 13.4).

CMA members published:
- 111 refereed articles in international journals,
- 3 books,
- 13 book chapters,
- 59 scientific reports, preprints, contributions, proceedings etc (not refereed), and had 14 media appearances, 6 on radio, 5 in newspapers, 1 in magazines, and 2 on internet-based media.

CMA members gave 173 talks outside CMA, of which:
- 8 scientific talks and 14 talks for a general audience in Norway,
- 151 scientific talks abroad, in 28 different countries.

CMA hosted:
- 8 conferences/workshops with 212 participants (35 international, 92 national, and 85 CMA-members), in which 92 scientific talks were given:
  - 53 by CMA members,
  - 29 by national guests,
  - 30 by international guests.
- 4 seminar series, in which 55 scientific talks were given:
  - 19 by CMA members,
  - 4 by national guests,
  - 32 by international guests.
- 2 lecture series on selected topics, in which 44 lectures were given, all by CMA members.

Finally CMA also co-organized 21 other international workshops and conferences.
SUMMARY

OVERALL REMARKS AND MAIN IMPRESSIONS OF 2006

In 2006 a central issue was the official midway evaluation process, initiated and executed by The Research Council of Norway (RCN). We have dedicated a separate section below for a summary of that process and its truly pleasant outcome.

In terms of our basic missions, research and research training, 2006 has again been highly productive, and many results have been achieved. We are still enthusiastic about the opportunity which the Centre of Excellence-scheme provides us with respect to performing important research and research training. We are grateful to the RCN and to our host, the University of Oslo, for providing excellent conditions.

We have followed the main lines of our research plan, and we have obtained outstanding results on many parts of it. There is a continuously growing number of published papers with interdisciplinary results. Our experience is that the plan is well founded, and still serves as intended with challenging, but realistic goals. We focus on establishing good research relations, within the centre, and with partners outside. New CMA members have been employed with preferences to the focused areas of the research plan. Financial resources are targeted towards research activities that support the plan. The total scientific activity of the centre fits the plan very well.

Many seminar series and workshops have been arranged, with extensive external participation. Numerous guests have been received. CMA members have participated and contributed to research events in all parts of the world. The cooperation with SINTEF is fruitful to both parties, and new items to this collaboration have been added. We have committed ourselves to several national and international collaborations. Hence we regard ourselves as highly active and visible on the national and international scene of mathematics and its applications.

Our basic missions are research and research training. However, we have also taken a leading role in a project called Computers in Science Education. The key idea is to include computations in teaching at all levels, thus supporting our core vision, and a natural consequence of the message of our research. Our efforts have gained considerable recognition and impact. Our host has granted us considerable funding as well as having included this project in their long-term strategy.

We continue to outperform all financial estimates of the original plan. Total revenues in 2006 were MNOK 43.1.

THE 2006 MIDWAY EVALUATION PROCESS

The Centre of Excellence scheme, as announced by RCN in the call for applications in 2001, included a midway evaluation process. This was to take place 3 ½ years after a centre’s starting date and conclusions were to be drawn within 6 months later. Prior to the evaluation process itself, CMA submitted an extensive self evaluation report on May 1, 2006. The RCN maintained their schedule, and the process took place during the summer/autumn of 2006. The report from the international scientific committee, and the final decisions made by the board of RCN, were communicated to us on December 15, 2006.

The overall conclusion on CMA reads:

The CMA has the potential to become, in fact it already is, a dynamo for computational mathematics and modeling in Northern Europe and a highly visible player globally. Overall evaluation: Exceptionally Good.

Below is a collection of other statements, made by the referees or the scientific committee:

The research produced within the centre is at the absolute forefront internationally in all of its 4 main areas…

…As for the number of publications, the record is outstanding. The staff published many high quality papers and many of publications in internationally recognized journals are outstanding…

…Apart from being a breeding ground for breakthroughs in mathematical science, the interdisciplinary focus of the centre is ideal to also impact the industry, the financial and medical sector as well as the utility producers. From this respect, CMA is a unique centre…

…the researcher training has been excellent…

We are proud of the evaluation results, and they encourage us to maintain and even strengthen our efforts in conducting top class research for a second five-year period.

The self evaluation reports, the three individual expert referee reports, and the final evaluation and remarks from the scientific committee and board of RCN, can all be downloaded from http://www.cma.uio.no/
a complex single-particle basis will allow us to address several important questions in nuclear many-body theory. The inclusion of three-body forces and pertinent effective interactions with physics, in particular since the experimental programs are pushing the limits of stability for nuclear matter, and hold great promise for ab initio calculations of heavier nuclei. The inclusion of three-body forces and pertinent effective interactions with a complex single-particle basis will allow us to address several important questions in nuclear many-body theory.

While working on techniques for smoothly gluing together parametric surfaces Mike Floater and Tom Lyche discovered two chain rules for divided differences that generalize the famous Faa di Bruno formula for derivatives of composite functions. The paper has generated a lot of interest, and further work by the authors led to a remarkable formula for divided differences of functional inverses, which is expressed in terms of partitions of a convex polygon.

Kenneth H. Karlsen and Nils H. Risebro, together with Giuseppe M. Coclite, University of Bari, Italy, made a breakthrough in the numerical analysis for the Camassa-Holm equation. The Camassa-Holm equation is a prototype of a class of nonlinear wave equations and models surface waves as well as waves in elastic materials. It has appeared difficult to construct finite difference schemes for this equation for which one can prove rigorously the convergence to an exact solution. This fact is related to the nonlinear and non-local features of the equation, and it has been observed that certain "natural" schemes either diverge or converge to the wrong solution. In this work the authors have constructed a finite difference scheme which indeed converges to a weak solution.

Ragnar Winther, together with Douglas N. Arnold, University of Minnesota, USA and Richard S. Falk, Rutgers University, USA, has written a paper which sets the scene for a range of problems related to exterior calculus, differential forms, and numerical analysis. The theory has applications to the construction of numerical methods for electromagnetism and elasticity. A collection of new techniques and results are presented on topics like polynomial and piecewise polynomial differential forms, smoothed projections, numerical approximation of the Hodge Laplace problem, preconditioning, and mixed finite element methods.

Fingers of "cool" plasma with a temperature of 10 000 K extend several thousand kilometers into the million degree solar corona. They may have a large influence on the dynamics and energy balance of the outer solar atmosphere but a convincing case has hitherto not been made for any of the many ideas for their explanation. Viggjo Haranste, Luc Rioppe van der Voort and Mats Carlsson, together with Bart De Pontieu, Lockheed Martin Solar and Astrophysics Laboratory, USA, and Michel van Noort, Institute for Solar Physics of the Royal Swedish Academy of Sciences, have combined numerical simulations and very high resolution new observations to show that these energetic phenomena can be explained by single strong acoustic shocks.

The collaboration between CMA, Oak Ridge National Laboratory, USA, and Michigan State University, USA, has resulted in several papers. A main emphasis is put on the coupled cluster method and recent results now allow us to perform ab initio calculations of both stable and unstable nuclei. We have developed a formalism which allows for a complex single-particle basis that includes bound, resonant and non-resonant continuum states. Our present codes can treat a single-basis which includes almost 1000 single-particle states. Furthermore, ORNLs and CMA’s Gaute Hagen, together with David Dean, ORNL and adjunct professor at CMA, and Thomas Papenbrock at ORNL, have included the calculation of triples correlations and three-body forces in the coupled cluster formalism. These calculations reproduce other benchmark calculations of few-body systems. This represents a major breakthrough for ab initio calculations of systems with many interacting particles in nuclear physics, in particular since the experimental programs are pushing the limits of stability for nuclear matter, and hold great promise for ab initio calculations of heavier nuclei. The inclusion of three-body forces and pertinent effective interactions with a complex single-particle basis will allow us to address several important questions in nuclear many-body theory.

The main goal of the research activity at CMA is to create a leading international centre for mathematics motivated form various areas of applications. From the start the centre was built around established research activities at the University in Oslo in geometry, stochastic analysis, differential equations, and applications in physical sciences, and where the activity in physical sciences is focused around computational astrophysics and computational quantum mechanics. In addition to preserve the high level activity in these areas, a central idea behind the establishment of the CMA is to create new interdisciplinary research activity based on the interplay between these areas. Even if most of the reported scientific work below can be characterized as either geometry, stochastic analysis, differential equations, quantum mechanics or astrophysics, we see a clear trend in the direction of more interdisciplinary projects. In particular, many of the Ph.D. fellows and postdocs are working with such problems at the moment.

Our vision is to create an environment where theory, computations, and applications are strongly interconnected. We believe that the development of numerical simulations is still at a very early stage, and that further theoretical development in this field will be strongly influenced by classical mathematical theories and complex applications in science and industry. The research activity reported below is in a good agreement with this vision.

**SELECTED RESEARCH HIGHLIGHTS**

**INTRODUCTION**

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**SCIENTIFIC ACHIEVEMENTS – GEOMETRY**

The activity in geometry is focused on geometric modeling. Many scientific and industrial problems require a digital description of geometry. The research at CMA in this area is based on combining techniques and theory from splines and mesh based modeling, algebraic methods and differential equation methods.

- **Senior scientists:** Geir Dahl, Michael Floater, Tom Lyche, Knut Merken, and Ragni Plene, Adjunct researchers: Tor Dokken, Truls Flattberg, Ewald Quaak, Egil Samset, and Stein Arild Stremme
- Postdoc fellows: Martin Reimers
- PhD students: Solveig Bruvoll, Christopher Dyken, Jon M. Holmervik, Pål Harum Johansen, Heidi Mork, Georg Muntingh, Atgeirr F. Rasmussen, Christian Schulz, and Johan S. Seland, have been connected to the group in 2006.

Based on their new algorithm for computing zeros of splines, Merken, together with Reimers and Schulz, have developed a new algorithm for computing transversal intersections of planar spline curves. With Lycke and F. Pelosi (Siena, Italy), Merken has also developed a multi resolution analysis based on linear splines which is stable in the uniform norm, independently of the knots. Merken and Reimers have also improved their new algorithm for computing zeros of splines in order to work better for multiple zeros. Together with Samset, Merken is supervising a number of master students in fields related to medical imaging. With Tai (from the PDE group), Samset and Merken also received funding from the Norwegian Research Council for a project focused on the registration problem in medical imaging.

Together with Mork and Plene has been studying real algebraic curves and surfaces, with a view towards geometric modeling. Johansen worked on the stratification of the space of quartic monoid real and complex surfaces. He defended his Ph.D. thesis “Topics in algebraic geometry and geometric modeling” in December 2006. Mork has started to work on real polar varieties, which has applications in algorithms to find points on the real components of a given variety.
Mork and Piene have written a paper on polar varieties for curves. Piene has been collaborating with A. Larten (Torino, Italy) and R. Mallavibarrena (Madrid, Spain) on the geometry of projective ruled varieties; their paper “Inflectional loci of scrolls” was submitted in December. Piene also continues to collaborate with S. Kleiman (MIT, USA) on problems in enumerative algebraic geometry, related to string theory in physics.

Lyche has continued to work on subdivision schemes together with J.-L. Merrien (Rennes, France). A paper on Hermite subdivision with shape constraints on a rectangular mesh has appeared. Lyche and M.-L. Mazure (Grenoble, France) have published a paper on total positivity and the existence of piecewise exponential B-splines, and together with K. Scherer (Bonn, Germany). Lyche have written a paper on mixed norm condition numbers for the univariate Bernstein basis.

Reimers continued research on numerical methods based on B-spline knot insertion. Algorithms for computing spline zeros with multiplicities and extremal points where developed and later teamed up Johan Selander to use these techniques for GPU based raytracing of algebraic surfaces. Reimers also supervised a PhD student at the Interventional Centre, resulting in a paper on GPU-based mesh collision detection. Together with Dyken, Reimers, and Selander also finished their research on GPU-based silhouette refinement on triangle meshes, resulting in a paper “Real-Time GPU Silhouette Refined using adaptively blended Bezier Patches”. The algorithm employs the “histogram pyramid”-method, developed by G. Ziegler at MPI, Germany. Dyken and Ziegler have continued to research other uses of the HP-method.

Rasmussen and Floater have continued to work on point-based methods for computing curve lengths and surface areas, and completed a paper with S. Reif (Potzdam, Germany) on Richardson extrapolation. Rasmussen and Floater have continued to work on PDE approaches to computing surface parameterizations, working jointly with Riese in the PDE group. Floater and K. Hormann (Clausthal, Germany) published papers on an extension of mean value coordinates, showing that they are well-defined in the whole plane, and on a generalization of Berrut’s barycentric rational interpolation to arbitrary degree. Floater and visitor T. Vololide (Leuven, Belgium) used the newly-purchased CMA 3D Minolta scanner to scan various objects and developed a new triangulation algorithm for the data sets. The paper is already accepted for publication.

Selander and Dokken have addressed the topic of real-time visualization of algebraic surfaces using programmable graphics cards. The results were presented as a poster on Supercomputing 2006. The paper will be published in a Springer book in 2007. A patent application addressing the use of data stream processors for generating raster data, with a specialization to the real time visualization of algebraic surfaces, was submitted in June 2006.

The research activity in Linear algebra and optimization is led by Dahl and falls into the two areas, Combinatorial matrix theory (A), and Discrete optimization (B). In area A Dahl has an ongoing collaboration with R. A. Brualdi (Wisconsin, USA) where properties of classes of (0,1)-matrices with additional structural properties are investigated (properties like nonzero patterns and fixed line sums, Bruhat shadows etc.) This has resulted in several published papers, as well conference presentations. In area B Dahl has collaboration with several groups. Together with Flathberg, there is an ongoing activity related to optimization and reconstruction of discrete images. Moreover, a journal paper by Dahl and his former PhD-student N. Foldnes treats theory and algorithms for knapsack problems with assignment restrictions. Dahl, together with a research group in France-Holland, also published a paper on polynomials associated with edge-disjoint paths, and Dahl, with a research group in Portugal, published a paper on spanning tree models and algorithms. Dahl also has a collaboration with the Institute of Transport Economics (in Oslo) with research focused on mathematical problems (theory, models and algorithms) in connection with analytical problems in the transportation area, which so far has led to one accepted paper.

Scientific Achievements – Stochastic Analysis

The stochastic analysis group has continued their research in mathematical finance and applications. During 2006, the group has been involved in many research papers, organization of international research conferences and development of new teaching material.

- Senior researchers: Fred Espen Benth, Giulia Di Nunno, Tom Lindstrom, and Bernt Øksendal.
- Adjunct researchers: Kjell Arne Brekke, Yaqiong Hu, Tusheng Zhang, and Knut Aase
- Postdoc fellows: Thilo Meyer-Brandis, Frank Proske, and Mikael Signali
- PhD-students: Andrea Barth, Eliot Chikouza, Inge B. Esle, Martin Grath, Paul C. Ketter, Rodwell Kafakunesu, Sure Mataramvura, An Ta Th Kieu; Olli Wallin, and Yeliz Yolcu Okur

During 2006 the group has been heavily involved in the research network AMaMeF “Advanced Mathematical Methods for Finance”, chaired by Øksendal and Di Nunno. This represents at present the large network for research in mathematical finance in Europe. The activities related to this network range from providing means for organizing conferences and open platforms for discussions of present research items, to grants and funding for research visits and exchanges. It reaches both the academic world at all levels and the private industry. Furthermore, Øksendal continues as the Norwegian coordinator for the NIFU program “Mathematical Modelling”, which has produced more than 80 Masters Candidates in Mathematics for the Southern African region since it started in 1996. The stochastic analysis group has been involved in the organization of several workshops and conferences, abroad and at a national level.

Øksendal has continued his research collaboration with Di Nunno, Hu, Proske, Zhang, and A. Sulem (INRIA, France) on the development of the theory of Malliavin calculus for Levy processes and its applications to stochastic control and finance. In addition he has started working with X Zhou (Hong Kong) on the same topic. In more detail, Hu and Øksendal have continued a project on how to find the optimal stopping time if one has advanced information. This is related to the insider trading problems already studied by some members of the CMA stochastic analysis group, but optimal stopping represents a new challenge which requires new methods. Øksendal and Zhou have managed to obtain a new maximum principle (of necessary type) for stochastic control, valid for general, possibly non-Markovian jump diffusion systems and even with partial information. Here the classical, and difficult, adjoint system of BSDEs is replaced by an expression involving Malliavin derivatives. This achievement is now being followed up in a new joint project where Proske and H. Salliah (Oslo), together with Øksendal and Zhou, are applying this method to optimal control of stochastic partial differential equations, with applications to interest rate theory. Øksendal and Sulem have introduced a new pricing rule in incomplete markets, namely “the risk indifference pricing principle”. This principle involves stochastic differential games and the corresponding HJB-Isaacs equation.

In addition Øksendal has been involved in several book projects in 2006:

- (iii) The Second Edition of his book with Holden (from the PDE group), Jan Ubøe (Bergen) and Zhang, entitled “Stochastic Partial Differential Equations” (Birkhauser).
- (iv) His new book with F. Biagini (München), Hu, and Zhang, entitled “Stochastic Calculus for Fractional Brownian Motion and Applications” (to be published by Springer).
- (v) His new book with Di Nunno and Proske, entitled “Malliavin Calculus for Levy Processes and Applications to Finance” (to be published by Springer).
D. Nuno and Øksendal study the characterization of the existence of a solution in an optimal portfolio problem with general utility function under partial information. This problem is interesting for its applications to finance and also for the mathematics involved, in fact standard methods may not be applied being the framework non-Markovian in general. The solution proposed uses methods of anticipating Malliavin/Skorohod type calculus.

D. Nuno has continued her research in stochastic calculus of the Malliavin/Skorohod type on random fields, this setting extends the calculus with respect to additive and Levy processes. This has resulted in two papers; the first one presents some computational formula for the derivative of the Ito non-anticipating integral. The second one, jointly written with Y. A. Rozanov (Milan, Italy) surveys the state of the research in this direction and presents some new results with respect to the derivation in the anticipating calculus of the Malliavin/Skorohod type.

Berth has continued his research on problems related to the electricity markets. In a paper with S. Koekebakker and F. Ollmar (both Kristiansand) a smoothing algorithm for construction of forward curves in the electricity market is proposed and analyzed. The method is applied as a tool to reconstruct smooth forward prices from observed swap prices. In a paper with Kettler, a new non-symmetric copula for modelling the dependency between gas and electricity prices is proposed. The copula is applied in connection with pricing of spark spread options, where we show that the prices are robust with respect to different types of dependency models. Perhaps most notably, in a paper with A. Carlesa (London, UK) and R. Kiesel (Ulm, Germany) we explain sign of the market price of risk in the electricity and gas markets by using a certainty equivalent principle for pricing forwards. The starting point is an additive mean-reversion process with jumps modeling the spot price dynamics. The forward price is derived as the certainty equivalent, which leads to a dynamics for this which may have a change in sign over the term structure curve. This provides an insight into the question of why the market price of risk may change sign in these markets.

In collaboration with Groth and Kufakunse, Berth have worked out prices for different types of volatility and variance options based on the stochastic volatility model of Barndorff-Nielsen and Shephard. The prices are efficiently computable by Fourier inversion techniques.

Over some years, Berth and J. Slatyet-Benth (Akershus, Norway) have worked on modeling of temperatures and pricing of weather derivatives. Together with Koekebakker, a continuous higher-order autoregressive model is proposed for temperature. The model generalizes earlier work, and turns out to fit observed temperature recordings very well. An interesting and new insight implied from this model is the fact that the volatility of temperature based futures will not have a consistently increasing volatility with decreasing time to maturity, but it may become decreasing. This is coined the modified Samuelson effect, and is a result of the long memory of temperature variations. This has consequences for pricing and risk management.

A large part of Christiansen and Winther’s activity has been devoted to the further development of finite element exterior calculus, a research topic which is closely related to Christiansen’s EURYI project on Numerical analysis and simulation of geometric wave equations. Winther’s joint paper with D. N. Arnold, (Minnesota, USA) and R. S. Falk (Rutgers, USA) called “Finite element exterior calculus, homological techniques and applications” was written by invitation for the journal Acta Numerica. This paper sets the scene for a range of problems related to exterior calculus, differential forms, and numerical analysis. In addition to serve as an ordinary survey paper, a collection of new techniques and results are also presented on topics like polynomial and piecewise polynomial differential forms, smoothed projections for finite elements, numerical approximation of the Hodge Laplace problem, preconditioning, and mixed finite elements for linear elasticity. In a later paper by Christiansen and Winther they have further improved the theory for smoothed projections such that undesired assumptions on boundary conditions and mesh regularity are removed, enabling one to prove stability and compactness properties of Hodge decompositions in the more general case.

Christiansen has also developed a way of constructing finite element spaces of differential forms on general polyhedra. They satisfy a commuting diagram linking them to the cellular cochain complex, the same way as Whitney forms are linked to the simplicial cochain complex, and the construction will potentially have applications for finite element methods with respect to non simplicial meshes or mimetic finite difference methods.

Tai has worked on image processing based partial differential equations. He has proposed and developed some new methodologies for solving interface problems. This has applications in image segmentation, optimal shape design problems related to inverse problems. He has also worked on fast solvers for the new models. He has arranged a joint CMA-CIPR workshop with 36 international participants. Typical examples of his research are the two papers dealing with variants of level set methods published jointly with two of his former PhD students, M. Lyons and J. Lie. In a joint paper with G. Hu (Beijing, China), Tai and Winther have discussed a saddle point approach to the computation of generalized harmonic maps. The methods proposed lead to the study of numerical approximations of nonlinear saddle point problems. In the paper convergence theory and preconditioning of such systems are studied.

Lie and Tai, together with T. Chan and S. Osher (both UCLA, USA), have edited the book “Image Processing Based on Partial Differential Equations”, published by Springer Verlag. The book contains 21 original scientific research articles that address state-of-the-art in using PDEs for image and signal processing.

Lie and Nørvåg have developed a new method for computing multiphase and multiphase transport in porous media in the absence of gravity and capillary forces. The method consists of an implicit temporal discretization in combination with compact high-order spatial discretisations based on an upwinded discontinuous Galerkin formulation. The resulting method is a highly efficient alternative to streamline methods and is capable of computing models with multimilllion cells in a few minutes on a standard desktop PC.

Lie, Hagen, and Nørvåg have continued to develop new methods for utilizing programmable graphics cards (GPUs) to accelerate numerical solution of partial differential equations, and they have published a paper on solving the Euler equations in 2D and 3D.

During 2006 CMA and the Centre for Integrated Petroleum Research, University of Bergen initiated cooperation on the mathematics of reservoir characterization based on electromagnetic data. As a consequence of this, Klausen has been awarded a new three year postdoc fellowship funded by Statoil.

The activity of Karlsen, Risebro, Holden, and their postdocs and students, is devoted to research in modern nonlinear analysis of partial differential equations and numerical methods. The emphasis is on differential equations that are relevant to applications, including solid-liquid separation processes, porous media flows, multi-phase fluid flows, traffic flows, water waves, and finance. During 2006 the group submitted more than 25 papers to international journals, many of which are already accepted for publication.
Karlsen and Biwaa, together with E. Jakobsen (Trondheim) have derived error estimates for certain approximate solutions of Bellman equations associated to a class of controlled jump-diffusion (Lvy) processes. These Bellman equations are fully nonlinear degenerate integro-PDEs interpreted in the sense of viscosity solutions. The approximate solutions are generated by an implicit finite difference-quadrature scheme. Karlsen and Evje have formulated a hierarchy of models relevant for studying coupled well-reservoir flows. The starting point is an integral equation representing unsteady single-phase 3-D porous media flow and the 1-D isothermal Euler equations representing unsteady well flow. This 2+2 system of conservation laws is coupled to the integral equation through natural coupling conditions accounting for the flow between well and surrounding reservoir. By imposing simplifying assumptions we obtain various hyperbolic-parabolic and hyperbolic-elliptic systems.

Hilden, together with X. Raynaud (Trondheim), have developed a new method for the Camassa-Holm equation by rewriting it as a system of ordinary differential equations taking values in a Banach space. The new ingredient is that the transformation corresponds to the transformation from Eulerian to Lagrangian variables. A new and stronger well-posedness result is then obtained. Holden and Karlsen, together with G. Coclite (Bari, Italy), considered higher-order Camassa-Holm equations describing exponential curves of the manifold of smooth orientation preserving diffeomorphisms of the unit circle in the plane. They have established the existence of a strongly continuous semigroup of global weak solutions. In addition, they have presented some invariant spaces under the action of that semigroup. Furthermore, Karlsen and Risebro, together with Coclite, made a breakthrough in the numerical analysis of the Camassa-Holm equation. Holden, together with Coclite, have studied the Schrödinger- Maxwell system with an additional potential that is localized to a point. This gives additional technical problems in the definition of the equation as well as its solution.

Karlsen and Risebro, together with Coclite, continue their investigation of the Degasperis-Procesi equation in classes of discontinuous functions. The Degasperis-Procesi equation has a form and an interpretation similar to the Camassa-Holm shallow water wave equation. They have constructed numerical schemes and proved that they converge to entropy solutions. In addition, they provide several numerical examples accentuating that discontinuous (shock) solutions form independently of the smoothness of the initial data. In a different direction, Karlsen, together with Coclite, have proved uniqueness within a class of discontinuous solutions to the Degasperis-Procesi equation, replacing the Kruzkov-type entropy inequalities by an Oleinik-type estimate.

Karlsen, Risebro, and Mishra have studied finite volume schemes for triangular systems of conservation laws. Triangular systems of conservation laws arise in different physical models like oil reservoir simulations, and lead to hyperbolic equations with resonant behavior. They have devised finite volume schemes for 2+2 triangular systems and shown that they converge to the weak solutions of the systems. The schemes are of the Godunov type and are very easy to implement. In another paper these authors introduce a new class of well-balanced schemes for conservation laws with source terms based on a local discontinuous flux formulation. The key issue in designing numerical schemes for these equations is the resolution of steady states, which is here done by processing the source term by using a local discontinuous flux formulation. This results in schemes which resolve steady states to a very high degree of accuracy. The schemes outperform existing finite volume schemes considerably in their robustness and versatility. In addition, Karlsen, together with R. Bürger (Stuttgart, Germany), A. García (Santiago, Chile), and J. D. Towers (MiraCosta, USA), have proposed a new family of numerical schemes for kinematic flows, in which the velocity of each species of the dispersive phase is an explicitly given function of the vector of concentrations of all species. It is shown how a very simple scheme for the scalar case, which is adapted to the “concentration times velocity” structure of the flux, can be extended to kinematic models with phase velocities that change sign, flows with two or more species (the system case), and discontinuous flows. They have also developed a kinematic model of continuous separation and classification of polydispers suspensions.

Karlsen, Bendahmane, and J. M. Urbano (Coimbra, Portugal), have considered a fully parabolic model for chemotaxis with volume-filling effect and a nonlinear diffusion that degenerates in a two-sided fashion. They address the questions of existence of weak solutions and of their regularity. Mishra, together with Adimurthi (Bangalore, India) and GDV Gowda (Bangalore, India), have proved existence and stability of entropy solutions for conservation laws with discontinuous nonconvex fluxes. The fluxes can have finitely many extrema and adjacent fluxes can intersect in an arbitrary manner. They propose a concept of solutions termed as AB-entropy solutions which are characterized by interface connections. They prove existence and L^1 stability of these solutions for a fixed connection.

Risebro and Coclite have studied Hamilton-Jacobi equations, where the Hamiltonian depends discontinuously on both the spatial and temporal location. Their main result is the existence of viscosity solutions to the Cauchy problem, and that the front tracking algorithm yields an L^1 contractive semigroup. Evje and Fløtten, together with S Munkejord (Stavanger), developed a WIMF (weakly implicit mixture flux) scheme for the drift-flux two-phase flow model. The drift-flux model is suitable for describing bubbly two-phase mixtures. In a different direction, Evje and Fløtten, together with H.A. Friis, investigated a relation between pressure-based schemes and central schemes for hyperbolic conservation laws.

### Scientific Achievements – Astrophysics

The physical description of the outer stellar atmospheres results in large sets of coupled partial differential equations. There are major difficulties in constructing numerical methods for these equations related to highly nonlinear boundary terms and in developing proper boundary conditions, an activity pursued at CMA. In addition, the activity in astrophysics is focused on developing improved algorithms for studying stochastic fields in a sphere and applying them to data on the Cosmic Microwave Background.

- Senior scientists: Mats Carlsson, Viggo Hansteen, Egil Leir, and Per Barth Ulej
- Postdoc fellows: Hakon Dahle, Hans Kristian Eriksson, Boris Gudkieson, Frode Hansen, Luc Roupee van der Voort
- PhD students: Hans Kristian Eriksson, Åse Marit Jansen, and Man Anne Kille
- have been connected to the group in 2006.

One of the major specific goals of the physical applications project in the research plan is to «Complete a 3d Radiation-Magneto-HydroDynamic code with non-restrictive boundary conditions». In 2006 we have completed this task and the code is now capable of treating the whole outer solar atmosphere, from the convection zone to the corona, with a realistic description of the most important mechanisms of energy transport: convection, radiation and conduction. The boundary conditions allow the transmission of all wave modes without reflection through a formulation using the MHD equations in characteristic form. The code has been written using the Open-MP paradigm for parallelization such that it runs in parallel on shared memory systems. Parallelization using the MPI paradigm is currently being worked on.

It has long been surmised that convective motions below the photosphere are the ultimate source of the «mechanical» (as opposed to radiative) heat required to heat the outer solar layers. Whether this energy is transported in the form of waves or in the slower braiding of the solar magnetic field is not known. With the development of the 3d code mentioned above it is now finally possible to model all the relevant parts of these phenomena consistently.

Gudkieson has published several important papers on this problem, showing that braiding of the solar magnetic field can give the heating necessary to get a hot corona. In 2006 he showed that his models are compatible with a range of detailed observational diagnostics; this is in the first time a model constructed from first principles (rather than constructed with lots of free parameters tuned to reproduce observables) reproduce the observed emission measures and the observed distribution of average velocities as function of line formation temperature.

At the solar limb, observations show cold gas sticking out as dynamic short fingers, called spicules. Related phenomena are observed on the solar disk as dynamic filaments close to sunspots. Hansteen, Roupee van der Voort and Carlsson have shown that this long time riddle can be explained by single strong shocks accelerating the cool gas to speeds of 10-50 km/s with a following constant deceleration. This was achieved through combining 2D and 3D models with high resolution observations from the Swedish 1m solar telescope on La Palma.
In 2005 it was shown in a paper published in Nature that the energy flux of acoustic waves falls short by a factor of at least ten to balance the radiative losses of the solar chromosphere. In 2006 A. Fiossoum (Oslo) and Carlsson followed this up by getting new, tailored, observations. We used these to better determine the total acoustic energy as a function of frequency entering the solar chromosphere. Modelling was used to study the effect of limited spatial resolution in the observations on the determined acoustic energy fluxes. The previous conclusion is confirmed in this work.

Several papers used synthetic observations of our 3D models to study the diagnostic properties of commonly used spectral windows and to propose new observational diagnostics.

Coronal mass ejections can accelerate matter to very high velocities, 1000-2000 km/s, resulting in higher density structures injected into the solar wind. Ø. Lie-Svendsen (Oslo) and Leer have studied different acceleration mechanisms for these events and find that the acceleration by Alfvén waves (simulating expulsion of flux ropes) does not lead to the observed temperatures or ionization states in the structures. Thermal heating of coronal electrons and protons, on the other hand, lead to better agreement with observations.

The new set of transport equations for fully ionized gases that was developed earlier by Kille, Jane, Lie-Svendsen and Leer, has been used to study the abundance of helium and other elements in coronal loops and the expansion of the solar corona into interplanetary space in the form of a solar wind. It has been shown that the equations allow for a significant build-up of minor ions in coronal loops, and that they may allow for two different solar wind solutions, for a specified coronal heating function: When both hydrogen and helium are included in the model, we can find either a solution with a dense, helium-rich corona and a slow solar wind or a low density, hot corona and a fast solar wind. Whether we find a fast or a slow solar wind solution depends on the history of the system.

In cosmology, the important results by Eriksen, Hansen, Banday, Gorski & Lilje (2004) showing an anisotropy between entering the solar chromosphere. Modelling was used to study the effect of limited spatial resolution in the observations on the determined acoustic energy fluxes. The previous conclusion is confirmed in this work.

Several papers used synthetic observations of our 3D models to study the diagnostic properties of commonly used spectral windows and to propose new observational diagnostics.

The starting point for all of our investigations is the development of appropriate techniques for studying systems of many interacting particles, so-called many-body methods. The systems of interest span most of the fields in physics covered by non-relativistic quantum mechanics that is atomic, molecular, nuclear and solid-state physics and the physics of quantum liquids. Besides the importance for our basic understanding of quantum systems, the capability to handle numerically quantum mechanical systems with many degrees of freedom is of strategic importance for both the materials science and nanotechnology programs in Norway. Analytic solutions are rare or impossible to obtain. Thus to develop and study stable numerical schemes is of utter importance.

Senior scientists: Morten Hjorth-Jensen, Eivind Oanes

Adjunct researcher: David Dean

Postdoc fellows: Gaute Hagen, Emil Lundh, Halvor Mæl-Nilsen

PHD-students: Elise Borgli, Maxim Kartamyshev, Simeren Kjaal, Eirik Orum, Victoria Popsueva, Torquil M. Sørensen, have been connected to the group in 2006.

Several topics within partial differential equations applied to quantum mechanical problems have been studied. A central topic has been the development of variational discretization techniques, in particular conservative time evolution schemes for non-linear partial differential equations. Of special interest here is the application of properties of Bose-Einstein condensation and the dynamics of vortices in Bose-Einstein condensates. The vortex motion in a condensate with a non uniform background density, especially when the structure of the core is important, has also been studied, together with the stability of double quantized vortices forms. Other systems of great experimental and industrial interest currently are so-called quantum dots, electrons confined to small almost two-dimensional regions. There is a large experimental and theoretical activity on manipulation and control of such quantum mechanical systems. These are extremely promising candidates for building quantum computers. This needs to be accompanied with a theoretical understanding of the dynamics of these systems. The development of stable numerical schemes is crucial to this. In this connection the group has worked on both finite element methods with time-development of low-dimensional quantum mechanical systems such as quantum dots. Furthermore, detailed investigations of the stability of discretizations of classical N-body problems over long time intervals have been performed. Here emphasis has been on artificial resonances and how these might cause instabilities. The working hypothesis is that such instabilities are also present in PDEs, and that the theory can give a foundation for understanding conservative PDE discretizations.

Hjorth-Jensen has an ongoing activity on Monte Carlo methods. Together with collaborators and students from the Department of Physics large Monte Carlo codes, which can handle both variational and diffusion algorithms for bosonic and fermionic systems, have been implemented. The codes have been used to study Bose-Einstein condensations and quantum dots. The areas of application are mainly various aspects of Bose-Einstein condensation, with an emphasis on vortices and systems from solid state physics, quantum dots in particular. In agreement with the research plan of the CMA, collaboration between the stochastic analysis group and the quantum physics group has been initiated. This collaboration involves Berth, Signahl and Sørensen from the stochastic analysis group. The aim here is to study numerical algorithms for solving stochastic partial differential equations and improved algorithms for performing Monte Carlo calculations of systems at finite temperature.

A substantial part of the activity is a collaboration with groups at Oak Ridge National Laboratory and Michigan State University at East Lansing on non-perturbative renormalization of large classes of diagrams in many body physics. This project has already resulted in several articles, and several invited contributions to conferences and workshops. The project centers on the coupled cluster method and allows performing ab initio calculations of nuclear systems for nuclei greater than oxygen. Oxygen is presently the limit of two of the other much favored ab initio methods in nuclear many-body physics, namely Greens function Monte Carlo methods and the so-called no-core shell model approach. This work is also an example of a successful interdisciplinary collaboration between physicists and chemists. It also shows that coupled-cluster
Below we briefly present the main contents of our research events, bringing hundreds of national and international researchers together in stimulating collaboration and transfer of knowledge. For statistical details on participants and lectures, see Appendix 5. For even more details on speakers, participants, programs and abstracts, please consult the CMA web for a full and detailed overview.

Workshop: Computational methods in Astrophysical Problems
The use of computational methods as tools for understanding astrophysical phenomena has become indispensable. This informal workshop was devoted to various numerical aspects of systems of partial differential (and related) equations arising in an astrophysical context, and it brought together researchers in astrophysics (with computational emphasis) and researchers working in the area of partial differential equations and their numerical methods. Topics addressed included: Numerical methods for systems hyperbolic conservation laws, Astrophysical magnetohydrodynamics, Radiation hydrodynamics, Radiative transfer problems, Boundary conditions.

Workshop: Mathematical Finance for Electricity and Related Markets
From a mathematical finance point of view, the energy markets are different from the more traditional financial markets in many respects. The spot price dynamics have features like sudden spikes and complicated dependency structures. Futures contracts deliver over a period rather than at a fixed point in time, and the flora of exotic derivatives is rich, with products like spread and swing options. During this workshop, the speakers presented new results in the analysis of risk for the electricity and related markets. Topics included modeling of electricity futures and analysis of interruptible supply contracts in the gas market.

Conference: Trends in Mathematics for Applications
The conference was a follow-up of the 2003 Kick-Off for CMA, in which we presented some key research areas to be attacked from our recently established Centre of Excellence. The intentions in this follow-up were to present recent advances in the key areas of the CMA research plan. We had invited distinguished members of the international research community within these areas. Members of CMA also gave talks, presenting representative parts of CMA’s own contributions to achieved advances.

A CMA school: Computational Quantum Mechanics
The focus in this school for PhD- and master students was on partial differential equations (PDEs) in quantum physics. The aim was to introduce basic methods for discretization and time propagation of PDEs. We wanted to give the students knowledge and hands on experience of how to solve PDEs in a theoretical sound way. Special emphasis was put on the stability of the discretization in time, and modern techniques for conservative systems were introduced. Examples of problems were taken from physics applications such as the diffusion equation, the wave equation, and the linear and nonlinear Schrödinger equation.

13th Workshop in Mathematics & Economics: Mathematical Finance and Insurance
This is an annual event, the 12th in a row, all held by the stochastic Analysis group in Oslo. This year’s workshop was devoted to finance and insurance, and brought participants and speakers from both insurance companies and academia.

A Nordic PhD workshop in Mathematical Finance
The fourth annual PhD workshop in Mathematical Finance was hosted by CMA. After two years in Lund and last year in Uppsala this Swedish happening expanded to Norway. We invited at Swedish and Norwegian PhD students working in the field to come and present their research in an informal context.

Workshop: Geometrical Partial Differential Equations: Numerics and Applications
The purpose of this event was to bring together international experts and our local environment in Norway to discuss recent efforts and results for partial differential equations and geometrical approaches in applications. The application areas included, among others, the following topics: Image processing; Noise removal, segmentation, registration, edge detection, Level set methods for surfaces and applications to image analysis, image processing and inverse problems. Numerical methods for nonlinear geometrical partial differential equations.

Workshop: GPU as a Computational Resource
The main objective of the GPU project, and its activities, is to demonstrate to Norwegian (and international) industry the potential that lies in graphics hardware used as a high-performance computational engine. This will be achieved through building demo applications and prototype numerical libraries for graphic cards. Topics included in this event: Overview of problems addressed in the GPGPU-project, GPU Point List Generation through Histogram Pyramids, Implicit Surface Visualization Using Graphics Hardware, Inpainting on the GPU, Linear algebra in Matlab accelerated by the GPU.

The seminar series of 2006
In addition to the specific workshops presented above, a number of seminar and lecture series have taken place as usual. Appendix 5 provides the full lists.
**PRIZES AND AWARDS**

Postdoc fellow Hans Kristian Kamfjord Eriksen was awarded the traditional “H. M. King Harald’s Gold Medal”, which is annually presented to the author of last year’s best PhD-theses at UiO. Late 2005 Eriksen defended his thesis “Practical analysis of current and future CMB experiments”, and for this work he received the prestigious prize at a ceremony on Sep 1, 2006.

Together with his colleague, Associate Professor Steen Koekebakker at Agder College, Professor Fred Espen Benth, received the “2006 FIBE Prize”. The prize is announced by the Norwegian publishing house Cappelen together with The Norwegian School of Economy and Business Administration. Koekebakker and Benth received the prize for their common paper “Stochastic Modelling of Financial Electricity Contracts”.

**MANAGEMENT AND ADMINISTRATION**

Our management philosophy still stands: Firstly, all senior scientists at CMA have signed personal contracts in which they commit themselves to conduct research in line with the research plan of CMA. Secondly, we are focused when we write descriptions of scientific positions, and in ranking of applicants: we emphasize the interdisciplinary nature of CMA, both with respect to the different scientific fields, but also with respect to the balance between theoretical, applied, and computational experience and interests of the applicants. Thirdly, we only grant financial resources to research activities (seminars, workshops, guest researchers, travelling) that build on our research plan. In this way we fill our positions with candidates who have the desired academic profile. The commitments of the senior scientists and the daily research activities motivate all CMA members to pursue research in the direction of our stated goals in the research plan. The result so far, we feel, is an international community of a sufficient size to be able to address the ambitious goals stated in our research plan.

**MANAGEMENT PHILOSOPHY**

No changes have been made during 2006. Professor Ragnar Winther (Director), Professor Fred Espen Benth (Vice Director), and Helge Galdal (Administrative Director) constitute the daily leadership with authority to make day-to-day decisions on practical matters, financial transactions, research activities within the budget and the framework of the research plan.

Also the extended leadership, a group of principal investigators, broadly representing all research groups of CMA, has remained unchanged. Tom Lyche, Ragni Piene, Tor Dokken, Bernt Øksendal, Helge Holden, Morten Hjorth-Jensen, and Mats Carlsson still serve as a consensus and advisory council for the daily leading group, ensuring democratic and good decisions in important choices of paths. Topics that are typically addressed in this group are:

- Description of scientific positions for announcement texts
- Appointing evaluation committees
- Final ranking of applicants for scientific positions
- Budget disposals
- Participation (or not) in boundary research actions wrt. the CMA research plan
- Coordination of scientific texts for reports etc.

**DAILY LEADERSHIP**

**THE BOARD**

The governing board of CMA has for 2006 consisted of the following members:

- Kjell Bendiksen, chair, Managing Director of The Institute for Energy Technology
- Suzanne Lacasse, co-chair, Managing Director of The Norwegian Geotechnical Institute
- Trygve Helgaker, Professor at the Department of Chemistry, UiO
- Birger Kruse, Director of the Faculty of Mathematics and Natural Sciences, UiO
- Svein Longva, National mediator of Norway
The CMA board is a professional administrative board. None of its members are scientific experts within the specific research areas of CMA. Its authorities emphasize strategic and control functions, with clear instruction to approve budgets, accounts, and annual report. Also the evolution of the research plan is a major topic of the board, and in 2006, the midway evaluation was the main issue, also for the board and the scientific advisory board – see the next section.

The board reports to the Faculty management. It met twice in 2006, on January 26 and March 14.

SCIENTIFIC ADVISORY BOARD

CMA has chosen to distinguish between the business-like and the scientific content of the board activity. However, the board is still responsible overall for the research plan, the advisory board is appointed by the board without power to pass resolutions. The main subject for the advisory board is to critically investigate and compare our research plan with our actual work and progress, and to guide and suggest when changes or additions are implemented.

The Scientific Advisory Board consists of:
- Professor Helmut Pottmann, chair (Vienna University of Technology, Austria).
- Professor Douglas N. Arnold (Institute of Mathematics and its Applications (IMA), University of Minnesota, USA).
- Professor Tom Bogdan (High Altitude Observatory, National Center for Atmospheric Research, Boulder, USA), and
- Professor Ivar Ekeland (University of British Columbia, Vancouver, Canada).

The final self evaluation report of the midway evaluation process was influenced by the criticism and guiding of the advisory board. A subsequent consequence will be an adjusted research plan from 2008, in our second period as a Centre of Excellence.

ADMINISTRATIVE SUPPORT

CMA has one administrative employee, senior adviser Helge Galdal. He is a member of the centre leadership, acting as Ragnar Winther’s right hand, preparing general correspondence, reporting, board papers, budget and accounting figures, financial transactions, communications, web-pages etc. Another role of his is to inspire and help the centre researchers to write proposals for external funding. Finally he is responsible for coordinating the administrative functions which are “outsourced”, that is first line services, economy & book-keeping, IT-support, guest relations & bureaucracy, student’s administrations, personnel matters, and archives. Details on these services are outlined in previous annual reports, and need not be repeated.

We have established an effective administrative organization. As far as possible we utilize the existing professional organization. CMA contributes to the surrounding host units with financial support due to the extra load of work and services in the host organization. This system is cost-effective (much cheaper than building a separate CMA-administration to cover the same services). We are also confident that this system has helped CMA become an integrated part of a larger scientific community.

ECONOMY

STATEMENT ON THE ACCOUNTING AND BUDGETING PRINCIPLES

We now have four years experience of running a large and complex project within an established institution, for which the general accounting and budgeting principles do not fully match the nature and needs of a centre like CMA. However we are confident that our presentations give the true picture of the complete activity. See previous reports for more extensive descriptions.

TOTAL REVENUE AND EXPENDITURE FIGURES

Below the main figures are presented (More details, together with all notes, are presented in appendix 2 and 3). The three columns to the left present the figures from the CMA-specific account, meaning the funding and costs that we control ourselves. The next three columns present “representative” figures from host funded activity, from Sintef personnel and projects dedicated to CMA, and from project activity associated to CMA. With other words: Activities within CMA, but with the funding and costs outside CMA’s books. The three rightmost columns give the sums.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>CMA specific revenues</td>
<td>Additional CMA related rev.</td>
<td>Total revenues</td>
<td></td>
</tr>
<tr>
<td>Salary Costs</td>
<td>15 390</td>
<td>15 252</td>
<td>18 067</td>
</tr>
<tr>
<td>Indirect costs</td>
<td>2 450</td>
<td>2 554</td>
<td>2 812</td>
</tr>
<tr>
<td>Teaching serv</td>
<td>250</td>
<td>152</td>
<td>200</td>
</tr>
<tr>
<td>Equipment</td>
<td>350</td>
<td>323</td>
<td>600</td>
</tr>
<tr>
<td>Other</td>
<td>3 911</td>
<td>2 686</td>
<td>3 560</td>
</tr>
<tr>
<td>Sum expend.</td>
<td>22 351</td>
<td>20 967</td>
<td>25 239</td>
</tr>
<tr>
<td>Annual result</td>
<td>617</td>
<td>-963</td>
<td>245</td>
</tr>
<tr>
<td>Transferred</td>
<td>-3 191</td>
<td>-3 191</td>
<td>-4 154</td>
</tr>
<tr>
<td>For transfer</td>
<td>-2 574</td>
<td>-4 154</td>
<td>-3 909</td>
</tr>
</tbody>
</table>

Table 1: The CMA accounting figures for 2006 and corresponding budget figures for 2007. Negative figures mean income/surplus.
SOME MAIN CONCLUSIONS AND REMARKS

We continue to carry over a surplus between fiscal years. In 2006 the annual result brought a surplus of KNOK 963, out of which KNOK 345 come from project activity. Only considering the basic CoE funds from RCN and UiO), 2006 gave a minor surplus of approx. KNOK 218.

Out of the total carryover from 2006 to 2007 (MNOK 4.1), MNOK 1.5 now origin from basic CMA-activity, while MNOK 2.6 are tied to future bound obligations within the project portfolio.

We continue to grow in terms of activity and funding. The difference between budgeted and real income of the year is approx. MNOK 2.6. Recall that budgets in every annual report only contain confirmed activity at the time of writing. This means that this sum is the net result of newly generated project activity and other support.

As the figures also clearly demonstrates: Project activity is turned towards the centre itself as more and more of previous established activity is finished. This is a natural consequence, since less new project activity incets outside CMA.

We are comfortable with the presented figures. Our financial situation provides a foundation for a stable and flexible project management, which in turn make us able to run a healthy and highly competent organization.

CHANGES IN THE FINANCIAL PLAN

Changes in the UiO funding
In 2006 CMA has again experienced that its host has raised their contributions from original commitments, both with specific funding and related activities. These are the new items in 2006:

- Department of informatics has employed Solveig Brurell in a PhD position, and also provided Siri Øyen Larsen with a stipend for promising female researchers waiting for a possibility to apply for a PhD position. They are both included in the CMA community and hence add to the CMA-related figures. PhD student Christopher Dyken has been granted a fourth year after finishing his project-funded three years.
- CMA was granted a new, full PhD position in 2006, in which Georg Muntingh was employed.
- We received a renewed contribution, KNOK 350, to our “Computers in Science Education” project (see separate section).
- For 2007 we have already been granted new promises. The main issue is again our CSE project, which will receive KNOK 900 in 2007.

Changes in the SINTEF contributions
From 2006, we included a PhD student, Jostein Natvig, financed by Sintef, but fully supervised at CMA, in the representative figures. Otherwise, the contributions ran as expected. From 2007, a new RCN project, “Parallel 3D”, will bring new project activity, including two PhD-students, to the established cooperation between us. One of the PhDs will be employed at CMA.

Changes in the project portfolio
The full list of projects is presented in appendix 4. New activity (and not known in the 2005 report) in 2006 were:

- Through a VISTA initiative, our postdoc Runhild Aae Klausen succeeded in a proposal for a three-year position.
- Through the vVITA program of RCN, we succeeded in our proposal MATMED, bringing a total contribution of more than MNOK 6, and three PhD-students, over five years.
- NORAD has funded us a minor start-up project for a new mathematical centre in southern Africa, run by our stochastic analysis group.

The budget figures for 2007 are lower than 2006, despite these new contributions, which reflect that several projects have expired in 2006 or will do in 2007. We intend to compete with more proposals in the coming year, but it is not necessarily a goal to continue further growth.

Changes in the cost plan
Expenditures are close to budgets, except for operational costs for which we have overestimated the costs. We continue to experience that CMA personnel and incoming guests very often are (partly) covered from other sources. Furthermore, especially prices for air tickets continue to decrease, and this item alone saves us considerable amounts.

The most important resolution made in order to oppose the effects of unexpected savings, has been to advance the scheduled employment plan, which we again have done. We have also granted several prolongations of well-functioning fellows, and we have granted some of the PhD students additional time to finish up their degrees. In 2007 we have decided to support our host in upgrading the main server computer systems, which explains the estimated doubling of that item.

The full list of projects is presented in appendix 4. New activity (and not known in the 2005 report) in 2006 were:

- CMA has funded a PhD student, Andrea Barth, for one year. The final two years (from September 07) will be funded by German funds, most likely the DFG.
- We have entered an agreement with Oak Ridge National Laboratory, Tennessee, USA. ORNL is funding postdoc Gaute Hagen from Jan 06 to March 08, and CMA is responsible for the next two years (April 2008 – March 2010).
THE PEOPLE

STATUS AND SOME STATISTICS

On December 31, 2006, CMA consisted of 77 people. They are all presented in appendix 1, together with those who finished in 2006 (12) and those who are confirmed incoming in early 2007 (7). Hence the presented lists include a total of 96 names.

Only counting 2006-members (i.e. 96 - 7 = 89) we may present the following statistical details:

- 19 senior scientists, 36 PhD-students, 18 postdocs, 13 adjunct positions, 1 scientific programmer, 1 project coordinator, and 1 administrative officer
- 74 men and 15 women
- 57 native Norwegians and 32 with foreign nationalities (representing 17 different countries)

74 funded/employed by CMA, 28 by the host, 6 by SINTEF, and 23 through affiliated projects.

PERSON-YEAR PRODUCTION 2006 AND ESTIMATES FOR 2007

The careful reader will notice that the content of the latter bullet point above sums up to 94. This indicates that some members are tied to CMA through different funding sources, either through parallel contributions (like the SINTEF personnel), or through subsequent engagements (the host postpones affiliated projects, or CMA employs former affiliates and so on). Appendix 1 provides the details. Table 2 below is calculated with respect to all these details, providing the exact man year production figures of 2006, and new estimates for 2007. As in all budget presentations, we use conservative figures; only confirmed new persons and projects are included.

<table>
<thead>
<tr>
<th></th>
<th>CMA</th>
<th>UiO funded</th>
<th>Sintef</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>12.04</td>
<td>2.88</td>
<td>3.00</td>
<td>7.22</td>
<td>25.14</td>
</tr>
<tr>
<td>Postdocs</td>
<td>5.69</td>
<td>0.40</td>
<td>6.40</td>
<td>12.49</td>
<td></td>
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<tr>
<td>Senior scientists</td>
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<td>10.30</td>
<td>0.60</td>
<td>16.63</td>
<td></td>
</tr>
<tr>
<td>Tech/Adm</td>
<td>1.00</td>
<td>1.00</td>
<td>0.00</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>Sum</td>
<td>23.46</td>
<td>14.58</td>
<td>3.60</td>
<td>14.62</td>
<td>56.26</td>
</tr>
<tr>
<td>International guests</td>
<td>6.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>CMA</th>
<th>UiO funded</th>
<th>Sintef</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>11.28</td>
<td>4.42</td>
<td>2.58</td>
<td>6.97</td>
<td>25.25</td>
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<tr>
<td>Postdocs</td>
<td>5.42</td>
<td>0.00</td>
<td>0.00</td>
<td>5.24</td>
<td>10.66</td>
</tr>
<tr>
<td>Senior scientists</td>
<td>4.52</td>
<td>10.30</td>
<td>0.60</td>
<td>17.42</td>
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<tr>
<td>Tech/Adm</td>
<td>1.71</td>
<td>1.00</td>
<td>0.00</td>
<td>2.71</td>
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<tr>
<td>Sum</td>
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<td>15.72</td>
<td>3.18</td>
<td>13.21</td>
<td>56.04</td>
</tr>
<tr>
<td>International guests</td>
<td>7.00</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Table 2. Calculation of person-year production in CMA, taking the funding source into account.

TECHNICAL AND ADMINISTRATIVE STAFF

As described in the “Management and administration”-section, most of the daily administrative services are “outsourced”. We utilize the existing organization as optimal as we find possible. Hence the following persons provide valuable support to the CMA in daily life. Executive officer Dina Haraldsson and secretary Anita Smelby provide the reception service at the Department of Mathematics. Senior executive officer Diana Holand of Department of Mathematics provides help with Norwegian bureaucracy etc. Senior executive officer Jørg Gjestvang of Department of Mathematics is the book-keeper of CMA and also provides service on reports and analysis. Computer engineers Terje Kvernes and Bård Kristiansen of Department of Mathematics are responsible for technical support. Senior executive officer Grete Andresen of The Faculty of Mathematics and Natural Sciences is handling personnel matters. Several other people could have been mentioned, in the four host departments, the faculty, and in the central administration.

Administrative director Helge Galdal has, until now, been the only administrative person in the centre itself. He has been coordinating the functions and the support staff mentioned above. However, the centre has grown to a size much bigger than anticipated when the original agreement was made. Especially the IT-support functions have been at critical levels. In order to strengthen these vital functions, we have decided to employ one extra person, in a 50% position, throughout 2007. Lucy Karpen entered the position early 2007.

GUESTS

It is a privilege of ours to invite prominent guest researchers and speakers as well as close collaborators of our groups. In 2006, we have received 13 international guest researchers who stayed for more than 1 month (see appendix 6). These 13 contributed more than three full man years to CMA in 2006. In addition, we received 69 other international guests for periods of 1 – 30 days; the full list is presented in appendix 6. Altogether, they spent approximately 3 full man years at CMA in 2006. Finally, a large number of national guests have visited us, many of them several times. We have not accurately counted or registered these, neither have we calculated these in the person-year figures in table 2.
**RESEARCH EDUCATION**

A main goal of CMA is the training of new researchers. On December 31, 2006 32 PhD students and 14 postdoc fellows were active in the CMA. We can report from three doctoral defences in 2006:

- June 30, 2006: Mari Anne Killie defended her thesis: “Modeling element abundances in the solar atmosphere with improved transport equations” for the PhD degree. Her supervisor has been Professor Egi Leer.
- October 10, 2006: Jostein Natvig defended his thesis: “High-resolution methods for conservation laws in the geosciences” for the PhD degree. His supervisor has been Professor Nils Henrik Risebro. Natvig continues to work as a researcher at SINTEF Applied Mathematics.
- December 14, 2006: Pål Hermunn Johansen defended his thesis: “Topics in algebraic geometry and geometric modeling” for the PhD degree. His supervisor has been Professor Ragnar Piene. Johansen has entered a position as a university lecturer at NTNU, Trondheim.

All together 15 doctoral candidates have so far successfully finished their PhDs at CMA. In 2007, we expect that we will have eight new PhD defences at CMA, of which several are already scheduled. For comparison, our original ambitions were that 10 PhD-students should defend their theses during the first five years of CMA, and 25 during all 10 years (see the research plan). Our revised ambitions, presented in the midway evaluation process last year, now aim for 25 during the first five years, and 60 for the full 10-year period.

**RESEARCHER SCHOOL**

In earlier reports we have briefly described the system of researcher schools in Norway, and at Uio specifically. We maintain our status as a researcher school, and we receive an annual funding (NOK 50,000). In 2006, we had two special events, specifically targeted at our “researcher school trainees”:

- From August 14-19, we hosted a one-week “CMA school in computational quantum mechanics” with focus on partial differential equations (PDEs) in quantum physics. The aim was to introduce basic methods for discretization and time propagation of PDEs, and to give the students knowledge and hands on experience of how to solve PDEs in a theoretical sound way. The school was arranged by our own postdoc fellow Halvor Mœll Nilsen. 15 lectures were presented by himself (6), Professor Hans Petter Langtangen (6) and Associate professor Xing Cai (3), the two latter from Simula Research Laboratory. In addition, there were practical exercises with guidance each day. 16 young researchers participated, both from CMA and other research groups in Norway.
- On October 5-6, we hosted a “CMA PhD Workshop in Mathematical Finance”. After two years in Lund and last year in Uppsala, CMA took the responsibility for this fourth event in this series. Our own PhD student Martin Groth was the organizer, and the key idea is that Swedish and Norwegian PhD students working in the field present their research to each other in an informal context. There were 13 participants who gave 11 presentations during the two days.

**COTUTELLE AGREEMENTS**

We maintain the agreement with University of Grenoble, France regarding PhD-student Jon Møkkelsen Hjelmenvik, for a joint PhD degree between the two institutions. Scheduled termination / defence is in June 2008. No further agreements are made.

**BASIC EDUCATION**

CMA is devoted to researcher education, and is not supposed to take major responsibilities at bachelor or master level. Nevertheless, an entire period of study must consist of coherent parts. Moreover we are deeply interested in candidates/applicants to our PhD positions with a solid and adequate background with respect to our needs (and our conviction on how modern mathematics should be taught). This is partly why CMA has chosen to let the senior scientists continue to teach at all levels, and not restrict ourselves to do PhD supervision and advanced level teaching. Also our research plan signals this attitude. Based on the same philosophy, CMA has chosen to enter the responsibility for the following project:

**Bachelor level: Computers in Science Education**

This project was initiated in 2004 by staff from the CMA in cooperation with colleagues from the Departments of Mathematics and Physics. The aim is to renew the teaching of mathematics and science by including a computational perspective even in the elementary courses. The project has direct support in the strategic plan of the Faculty for Mathematics and Natural Sciences for the period 2005-2009.

The only way to reach the ambitious goals of the project, to renew the teaching of mathematics and the mathematical sciences by including a computational perspective on the central courses, is to get more of the Faculty’s scientific staff involved in this initiative. We have decided to do this by awarding small grants for travelling, equipment, assistants etc. to teachers who are willing to reform central courses in this direction. The financial support for this will come directly from the Faculty, and the grants will be available in 2007.

We also obtained added support from the University’s initiative for flexible teaching to further develop existing courses on numerical tools and programming languages like MATLAB, Fortran, C++ etc. These courses will be offered to staff members who feel that they need this kind of training. In response to a request from the bachelor programs in mathematics and the mathematically oriented sciences, the Department of Informatics has decided to offer a new basic programming course, designed specifically for these bachelor programs. This will provide an opportunity to offer an education where the computational perspective is fully integrated, at least for the first three seminars. The course is developed by staff at the Simula Research Laboratory and Department of Informatics, and will be given for the first time in the Fall of 2007.

Towards the end of 2006 a bimonthly seminar series was established, that will focus on the use of computations in the elementary teaching of science and mathematics. The project secured its links with the Faculty in 2006 and is now governed by a group consisting of Helge Gådal, Morten Hjorth-Jensen and Knut Merken from the CMA, together with Dean of Education Annik Myhre and Coordinator of Education Hanne Selna from the Faculty.

Morten Hjorth-Jensen and Knut Merken received the first CMA prize for their efforts with the CSE project.

**Master level:**

Rather than establishing separate master programs, CMA wants to influence on the existing programs by our ordinary and frequent teaching duties. This strategy is based on a confidence that the existing programs suit, and will continue to do so, our research profile. 2006 did not bring any changes or additions to these principles.
The CMA construction is based on a kernel of senior researchers from four different departments. All of them (except the Centre Director) are still closely connected to their home department through teaching duties. This is a conscious strategy on the part of CMA: we want to continue the development (and renewal) of the ordinary teaching in our basic subjects. Obviously, this demands a close and well-functioning cooperation between CMA and its host departments, and we feel that this is successful. Daily cooperation runs smoothly and efficiently. Moreover, CMA has taken a major responsibility in the internal project “Computers in Science Education”, which is outlined under heading “Basic Education” above.

Furthermore, all scientists in our host department are included in our weekly activity bulletin, and many of them frequently participate. The Centre Director and the Head of the Department of Mathematics regularly hold informal lunch meetings together with selected employees from both units. We also arrange social events together; in 2006 we had a common summer party and a Christmas lunch.

In late 2006, Sintef succeeded in their proposal for a new project named “Reservoir monitoring and dynamic reservoir characterization with electromagnetic data”. The project is run by CIPR, but CMA participates with one three-year postdoc fellow, Runhild Aae Klausen.

CMA has a large circle of international collaborators and networking. In 2006 we received 82 international guests (all listed in appendix 6), of which 13 stayed with us for more than 1 month.

All eight internally arranged conferences/workshops had international participation (Appendix 5a). CMA-members have been (co)organiser of 21 international conferences in addition to those at CMA (Appendix 5c). Among the 127 refereed articles (111), books (3) and book chapters (13), 72 were written together with international partners (Appendix 7a-c). Out of 159 scientific talks outside CMA (Appendix 8a and 8b), 151 were given abroad (in 29 different countries, on all continents).

Appendix 4 provides a full list of all projects at CMA, many of them with extensive international collaboration, and also some of them coordinated by CMA / CMA-members.

All these works and items point to an extensive research collaboration all over the world, showing our international participation and visibility. Most of the daily work is based on contacts established from researcher to researcher, and are not established as formal cooperative agreements. However, as a Centre of Excellence we also aim at establishing some formal and obliging institutional cooperation. Several examples are listed in previous reports. New items added in 2006 are:

- CMA, through its stochastic analysis group, participates in the Mathematical Modeling program for Southern Africa, based in Harare. In 2006 we were granted start-up funding from NORAD for establishing a new mathematical centre in the region. The subsequent main application is still pending.

- Through the formalized cooperation with the University of Botswana, we arranged the SAMSA (Southern African Mathematical Sciences Association) 2006 workshop (number 6) in Gaborone, Botswana in November/December 2006.

- We have an established collaboration with Oak Ridge National Lab (ORNL) in Tennessee, USA, described in earlier reports. In 2006 postdoc Gautre Hagen applied, and was ranked for, a new position at CMA. However, we made an agreement that he stays at the ORNL until March 2008, and then enters a 2-year position at CMA. He affiliates both institutions from 2006 – 2010.

- We have established an informal agreement with University of Mannheim, Germany / Professor Jürgen Potthoff, on common supervision and funding of PhD student Andrea Barth.
HEALTH, ENVIRONMENT AND SAFETY

CMA does not store chemicals or other possibly dangerous materials etc. No work-related accidents occurred in 2006.

During September/October we scheduled and ran formal individual appraisals with all our PhD- and postdoc fellows (those located in our premises). Necessary individual actions were performed, and some valuable information and feedback were collected.

The technical division of our host institution initiated an extensive renovation process of the building in which we are located. All windows were cleansed and repainted, and new automatic sun screens were mounted. The heating system was cleansed and improved, and a new ventilation system in the toilets and sanitary rooms is currently being installed.

For security reasons, all key cylinders of all doors are changed and a new key system introduced.

Of social and teambuilding character, we had a common dinner at the Ekeberg restaurant in June, and we arranged a prechristmas dinner in our own premises mid-December. During the autumn semester we frequently (6 times) arranged the *CMA seminar* which now consists of social gathering with coffee and refreshments, and short scientific presentation of the current work of our PhDs and postdocs.

PUBLIC OUTREACH

In 2006 we list the following items

- We have registered 14 media appearances, see appendix 9.
- Appendix 8c presents a list of 14 talks/presentations, given in 2006, meant for a general audience.
- We continued our sponsorship for www.matematikk.org, see description in former reports.

APPENDICES

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The following tables give a total overview of all CMA members in 2006 and in the foreseeable future. Some more positions will be announced by CMA itself during 2007, but if names are not known, these are not included in the lists. Any further speculations or not-yet-confirmed project fellows are also neglected (according to our budget philosophy we do not calculate any new contributions). Any such contributions provided from now on, will appear in the 2007 annual report.

The information provides the foundations for the accounts and budget disposals in this report, and also for the statistics on the personnel.

### SENIOR SCIENTISTS

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### PhD-STUDENTS

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<td>Norway</td>
<td>Nov05-Oct07</td>
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<td>Tore Halste Flaten</td>
<td>Norway</td>
<td>Feb05-Jan07</td>
<td>100%</td>
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<tr>
<td>Boris Goldkist</td>
<td>Denmark</td>
<td>Mar04-Mar07</td>
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<td>Gaute Hagen</td>
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<td>Frode K. Hansen</td>
<td>Norway</td>
<td>Feb05-Dec06</td>
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<tr>
<td>Runhild Aae Klausen</td>
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<td>Oct05-Dec06</td>
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<td>Emil Lundh</td>
<td>Sweden</td>
<td>Aug05-Jan06</td>
<td>100%</td>
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<td>Thilo Meyer-Brandis</td>
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<td>Mar05-Dec05</td>
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<td>Sidhartha Mishra</td>
<td>India</td>
<td>Sep05-Aug08</td>
<td>100%</td>
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<td>Per Christian Moan</td>
<td>Norway</td>
<td>Sep04-Apr06</td>
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<td>Halvor Mel Nilsen</td>
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<td>Dec04-Dec06</td>
<td>100%</td>
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<td>Frank Proske</td>
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<td>Magnus Svärd</td>
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### Other

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<td>Mar03-Feb08</td>
<td>100%</td>
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<td>Klara Hveberg</td>
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<td>Feb07-Jan08</td>
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<td>Siri Dyen Larsen</td>
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<td>Res. assistant</td>
<td>Jan07-Dec07</td>
<td>100%</td>
<td>Host</td>
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<td>Andrew McMurty</td>
<td>Ireland</td>
<td>Scientific prog</td>
<td>Oct03-Feb08</td>
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## APPENDIX 3

### NOTES ON ACCOUNTING 2006 AND BUDGET FIGURES 2007

1. **Accounted Revenues.** The top part of the table presents the cash income to CMA, 2006 accounted figures, and 2007 budgeted figures.

2. **RCN CoE-funding.** The original schedule is maintained, both for 2006 and 2007.

3. **Contributions from UIO.**

4. **Contributions from SINTEF.** One PhD student (full rate) from the GPU project (Johan Simon Seland) until July 31, 2007. One new PhD student in the new Parallel 3D – project from July 1, 2007.

5. **EU contributions.** The CENS-CMA project provided cash transfers from Estonia of NOK 157 in 2006, and we expect NOK 150 in 2007. We also expect a final payment in 2007 of around NOK 400 for the Marie Curie individual fellowship of postdoc Mikael Signahl.

6. **RCN projects.**
   - **2007 (NOK 1000):** YFF-project Kenneth Karlsen: 1667, EURYI project Snorre Christiansen: 2000, Individual Postdoc-grant Thilo Mayer-Brandis: 723, eVITA project *MATMED*: 1680, **Total: 6070**

7. **Other, state official contributions.**
   - **2007 (nothing specifically expected)**

8. **Private funding.**
   - **2006 (NOK 1000):** IRIS Research, Stavanger for hosting postdoc fellow TH Flåtten: 81,
   - **2007 (NOK 1000):** VISTA project *Reservoir monitoring and dynamical reservoir characterization with electromagnetic data*, postdoc Runhild Aas Klausen: 690.

9. **Accounted expenditures + representative revenues and expenditures.** The lower part of the table presents the accounted costs of CMA (under columns 3 and 4). In addition, since all non-accounted (representative) figures balance, we present these figures under the same headings, separated by columns to specify the contributions by funding sources.

10. **Salary costs for PhD students.** This item is covering salaries and direct costs thereof for all our PhD students in 2006, and those confirmed for 2007. The figures reflect the man year figures in table 3.

11. **Salary costs for postdoc positions.** As 10.

12. **Salary costs for researcher positions.** As 10. By “Researcher” we mean senior scientists (including the centre manager), adjunct positions, and project fellow in the CSE project.

13. **Salary costs for guests.** As 10. By “Guests” we count official long term guests (who stay full time with us for more than 1 month). They contribute to the CMA research similarly to CMA members, and we report their results from the visiting period. Salary costs are estimated at an average level, comparative to ordinary CMA members.

14. **Salary costs for administrative and technical personnel.** As 10. Recall that a major part of the indirect costs (note 15) is dedicated to cover administrative and technical support for the centre as described in section “Administrative support”. Hence this item covers senior advisor Helge Galdal and scientific programmer Andrew McMurry (2006 and 2007). From 2007 also computer engineer Lucy Karpen (50% position from Feb 1) and a new officer to handle international guests (50% position from July 1), are counted.

15. **Indirect costs, per individual.** This item covers offices and infrastructure provided for each individual. The rates for 2006 were 105,000/85,000 pr man-year for PhDs and postdocs / other. We explicitly pay, using these rates, our host for all CMA employees. Indirect costs for UIO funded personnel, SINTEF personnel and affiliates are represented with the same rates.

16. **Additional areas.** The amount appears in the original contract, and is specified to cover all areas beyond the offices counted in 15.

17. **Conferences.** Appendix 5 contains a full list of 2006 events, a year with no particularly expensive single events. 2007 will bring a couple of more extensive arrangements.

18. **Guests and travelling.** This item reflects another main activity. Appendix 6 and 8 presents the main results of this extensive bilateral activity.

19. **Public outreach.** This item covers publicity efforts, posters, design elements for web and brochures, reports (like this) etc. We also plan to make efforts towards society in general, and children specifically. The support of www.matematikk.org is included in this item.

20. **Teaching services.** CMA members are not exempted from teaching. On the contrary, we regard it as important that we keep up with the teaching duties of the scientific community. However, in order to relieve us the most time consuming parts of teaching, we have this specific budget item.

21. **Various operational costs.** This item is meant for the daily needs and actions that are not covered by any other specific item. Operational means for PhDs and postdocs are included. For recruiting positions, common practice is to set aside some personal means for operational costs. In CMA we calculate NOK 33,000 pr year for this purpose. All affiliates have the same sum available, and we have used the same rate for the host-supported fellows.

22. **Equipment.** CMA itself mostly obtains computers and additional accessories. The centre members also make use of existing equipment, especially the astrophysicists. In the original contracted budget we estimated this to a 2006 amount of NOK 541 (2006: 552). The activity goes on as expected, and we see no reasons to adjust this contribution to the figures.

23. **Annual Result.** We conclude the accounting year of 2005 with a surplus of NOK 963. 2007 is expected to bring a moderate deficit of NOK 99. See the main report for further comments.

24. **Transfers.** The CoE-scheme of RCN allows transfers, and to us this has been necessary to manage the financial effects of the delayed entry in the premises in 2003. Now, most transfers are due to new project activity.

25. **Accumulated result.** These figures reflect the balance sheet in table 2, or vice versa.
APPENDIX 4
LIST OF ASSOCIATED PROJECTS

INDIVIDUAL
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<th>Project leader/node</th>
<th>Period</th>
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<td>Hans Kristian K. Ericksen</td>
<td>PhD</td>
<td>NFR</td>
<td>157882/430</td>
<td>Per Liße</td>
<td>01.07.03 - 30.06.06</td>
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<tr>
<td>Mari Anne Klikke</td>
<td>PhD</td>
<td>NFR</td>
<td>153020/431</td>
<td>Øystein Lie-Svendsen</td>
<td>01.02.03 - 31.01.06</td>
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<td>Rodwell Kufakunesu</td>
<td>PhD</td>
<td>Univ.of Zimbabwe</td>
<td>160203/V30</td>
<td>Bernt Øksendal</td>
<td>05.05.04 - 30.04.07</td>
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<td>Paul C. Kettler</td>
<td>PhD</td>
<td>eVITA</td>
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<td>An Ta Thi Kieu</td>
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<td>Morten Hjort-Jensen</td>
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<td>Viggo Hansteen</td>
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<td>Solar Atmospheric Modelling</td>
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<td>SUPREMA</td>
<td>NFR / SUP</td>
<td>154077/400</td>
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<td>Mathematical Methods in Mesh-based</td>
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<td><em>Numerical Partial Differential Equations: Theory, Numerics, and Applications</em></td>
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<td>CENS-CMA</td>
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<td>Numerical Analysis and simulation of geometric wave equations</td>
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<td>173453/V30</td>
<td>Snorre Christiansen</td>
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<td>Mathematics and its Applications in Southern Africa</td>
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<td>01.10.06 - 30.09.10</td>
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APPENDIX 5
LIST OF CMA EVENTS 2006

1. Workshop: Computational Methods in Astrophysical Problems
   - January 9-10. Organized by Kenneth Karlsen and Nils Henrik Risebro, CMA. 20 participants: 3 international, 3 national, and 14 CMA members. 9 talks, 5 by international guests, 4 by CMA members

2. Workshop: Mathematical Finance for Electricity and Related Markets
   - March 29. Organized by Fred Espen Benth and Thilo Meyer-Brandis, CMA. 27 participants: 5 international, 15 national, and 7 CMA members. 8 talks, 2 by international guests, 3 by national guests, and 3 by CMA members

3. Conference: Trends in Mathematics for Applications
   - June 19-21. Organized by Giulia Di Nunno, Helge Galdal, Viggo Hansteen, Kenneth Karlse, Tom Lyche, and Ragnar Winther, CMA. 40 participants: 6 international, 4 national and 30 CMA members. 11 talks, 6 by international guests and 5 by CMA members

4. Researcher school: Computational Quantum Mechanics
   - August 14-19. Organized by Halvor Møll Nilsen, Helge Galdal, CMA, and Hans Petter LAngtangen, Xing Cai, Simula Research Laboratory. 16 participants: 1 international, 10 national, and 5 CMA members. 15 lectures (±10 lab sessions), 9 by national guests, and 6 by CMA members

5. Workshop: Risk measure and stochastic games with applications to finance and economics
   - September 29. Organized by Fred Espen Benth, Giulia Di Nunno, Tom Lindstrom, and Bernt Øksendal, CMA. 27 participants: 4 international, 11 national, and 12 CMA members. 7 talks, 2 by international guests, 4 by national guests, and 1 by CMA members

6. Researcher school: Mathematical Finance
   - October 5-6. Organized by Martin Groth, CMA. 13 participants: 8 international, and 5 CMA members. 11 talks, 8 by international guests, and 3 by CMA members

7. Workshop: Geometrical partial differential equations: numerics and applications
   - December 7-9. Organized by Xue-Cheng Tai (UiB/CMA), Antonio Zanna and Aride Lundeved (UiB/CMA). 40 participants: 8 international, 7 national, and 25 CMA members. 22 talks, 7 by international guests, 11 by national guests, and 4 by CMA members

8. Workshop: GPU as a Computational Resource
   - December 12. Organized by Tor Dokken (Sintef/CMA). 31 participants: 1 international, 24 national, and 6 CMA members. 9 talks, 2 by national guests, and 7 by CMA members

9. Workshops and conferences arranged at CMA
   - Appendix 4

10. Other
    - Appendix 5

11. **Through SiTeF**
    - Appendix 5

12. **AIM at SHAPE**
    - Appendix 5

13. **Graphics hardware as a high-end computational resource**
    - Appendix 5

14. **Parallel 3D**
    - Appendix 5

15. **Mathematical Methods in Mesh-based Geometric Modelling**
    - Appendix 5

16. **Parallel Geometric Modelling (PGM) of Wireframe Surfaces**
    - Appendix 5

17. **Mathematical and Computational Methods for Southern Africa**
    - Appendix 5

18. **Mathematical and computational methods**
    - Appendix 5

19. **Numerical Analysis and simulation of geometric wave equations**
    - Appendix 5

20. **Other**
    - Appendix 5

21. **Mathematics and its Applications in Southern Africa**
    - Appendix 5

22. **Mathematical and computational methods**
    - Appendix 5

23. **Wavemaker**
    - Appendix 5

24. **Intego PDEs**
    - Appendix 5

25. **Computers in Science Education**
    - Appendix 5

26. **THROUGH SiTeF**
    - Appendix 5

27. **AIM at SHAPE**
    - Appendix 5

28. **Graphics hardware as a high-end computational resource**
    - Appendix 5

29. **Parallel 3D**
    - Appendix 5
5b. Seminar and Lecture Series at CMA

1. CMA seminar series 2006
   Spring/fall. 9 seminars, 3 by international guests, 1 by national guests, and 5 by CMA members.

2. The CMA Guest Lectures 2005
   Spring/fall. 24 lectures, 22 by international guests, and 2 by national guests.

3. Lecture Series on Economics of Uncertainty
   Spring. 32 lectures, all by CMA's Adjunct Professor Knut Aase.

4. Lecture Series on Finite Element Exterior Calculus
   Fall. 12 lectures, all by CMA's Professor Ragnar Winther.

5. Stochastic Analysis Seminar
   Spring/fall. 16 seminars, 6 by international guests, and 10 by CMA members.

6. PDE seminar
   Fall. 6 seminars, 1 by international guests, 1 by national guest, and 4 by CMA members.

5c. International workshops and conferences, (co-)organized by CMA

1. The School on Tools and Toys in Nuclear Astrophysics
   Michigan State University, MI, USA, Feb. 13 - 17. Morten Hjorth-Jensen on the organizing committee.

2. Sixth Winter School in Computational Mathematics
   Geilo, March 5 -10. Knut-Andreas Lie on the organizing committee.

3. ECMI SIG Industry Challenges in Geometric Modeling and CAD 2006
   Darmstadt, Germany, March 9-10, 2006. CMA is co-sponsor. Ewald Quak is co-organizer.

4. Skinase 2006

5. First AMaMeF General Conference

6. International Symposium on Insurance and Finance

7. 3rd CENS-CMA Seminar

8. Scale Space Variational Methods 2007
   Ischia, Italy, May 30 - June 2, 2006. Xue-Cheng Tai is member of program committee.

9. Computational Algebraic Geometry and Applications
   Nice, France. June 2-6, 2006. Ragni Picioiu is member of the Program Committee.

10. 8th China-Norway-Sweden Workshop on Computational Mathematics

11. GPU as a computational Resource

12. IEEE Shape Modeling International
    Matsushima, Japan. June 14-16, 2006. Ewald Quak member of the Program Committee.

13. The Nuclei in the Cosmos IX Summer School


15. International Symposium on Nuclear Astrophysics - Nuclei in the Cosmos IX


17. International Workshop on Scientific Computing

18. Summer School on Applications of 3D Shapes: Ontologies, Software Tools and Industrial Case Studies

    Petrozavodsk, Russia. August 26-31 2006. CMA is co-sponsor. Bernt Øksendal and Knut Aase are on the scientific committee.

20. IST EVENT 2006 - Strategies for Leadership
    Helsinki, Finland. November 21-23, 2006. Ewald Quak co-organizer of AIM@Shape project stand: “Modelling and understanding knowledge related to visual media”.

21. SAMSA 2006
    Botswana. November 27 - December 2, 2006. CMA co-sponsor and Bernt Øksendal on the organizing committee.
INTERNATIONAL GUESTS OF CMA 2006

Appendix 6

Longer research visits (> 1 month)

- Sep 4 - Feb 28 (2007): Boris Andreianov, Université de Franche-Comté, Besançon, France
- Sep 1 - Oct 31: Carl Lindberg, Chalmers University, Goteborg, Sweden
- Aug 14 - Sep 26: Professor Michael Teishter University of Missouri, USA
- Aug 1 - Oct 31: PhD-student Christina Erwein, Brunel University West London, UK
- Jun 1 - Dec 31: Professor Tammo Soomere, CENS, Estonia
- May 1 - Jun 30: PhD-student Antonio Ivan Garcia Alvear, Chile
- Apr - 30: May 29: Professor Vidyaadhav Mundrekar Michigan State University, USA
- Apr 18 - Jul 28: Student Samuel Boucher, École Polytechnique, Paris, France
- Apr 3 - Sep 20: PhD student Björn Leenerts, Sterrekundig Instituut, Utrecht, Netherlands
- Mar 19 - Apr 18: PhD-student Tim Volodin, Katholieke Universiteit Leuven, Belgium
- Feb 1 - Apr 30: Professor Jean Keita, CENS, Estonia
- Jan 25 - Jun 30: PhD-student Ole Nilsson
- Nov 21 (2005) - Feb 20: Professor Tammo Soomere, CENS, Estonia

Short term guests (<1 month)

- Dec 12: Mario Martínez Zartzu, University of Valladolid, Spain
- Dec 6-7: A CIPR-CMA Workshop: Fiorella Spallari, University of Bologna, Italy, Serena Morighi, University of Bologna, Italy, Olmar Scherzer, University of Innsbruck, Austria, Anders Heyden, Malmö University, Sweden, François Louze, University of Copenhagen, Denmark, Stephan Didas, Saarland University, Germany
- Dec 1-16: Professor Evgenii Panov, Novgorod State University, Russia
- Nov 27-30: Professor Oleg Viro, University of Uppsala, Sweden
- Nov 22-24: Professor Peter Schröder, California Institute of Technology, USA
- Nov 20-24: Professor Alfio Borzi, University of Graz, Austria
- Oct 23 - Nov 10: PhD-student Tim Volodin, Katholieke Universiteit Leuven, Belgium
- Oct 11: Mattias Sandberg, KTH, Stockholm, Sweden
- Oct 5-6: A CMA PhD workshop in Mathematical Finance: Mats Broden, Lunds tekniska högskola, Sweden, Jonas Persson, Uppsala University, Sweden, Karl Larson, Lunds University, Sweden, Jonas Ströby, Lunds tekniska högskola, Sweden, Mia Hinnerich, Handelshögskolan, Sweden, Mikael Elhoub, Handelshögskolan, Sweden, Agatha Murgoci, Handelshögskolan, Sweden
- Oct 1-4: Associate Professor Friedrich Hubalek, Thiele Centre, University of Aarhus, Denmark
- Sep 27-29: Emanuela Rosazza Gianin, University of Naples, Italy
- Sep 27 - Oct 7: Stanislas Ouaou, Université de Ouagadougou, Burkina Faso
- Sep 25-29: Professor Raimund Bürger, Universität Stuttgart, Germany
- Sep 8-14: PhD-student Harish Kumar, ETH, Zurich, Switzerland
- Aug 18 - Sep 3: Professor Zvi Ziegler, Technion, Haifa, Israel
- Jul 31 - Aug 18: Dr. Bart De Pontieu, Lockheed Martin Solar and Astrophysics Laboratory, USA
- Jul 3-4: Professor Agnes Sulem, INRIA, France
- Jun 19-21: CMA conference (Trends in Mathematics for Applications): Matthew Bates, School of Physics, University of Exeter, UK, Sandy Davie, University of Edinburgh, Scotland, Ivan Ekeland, University of British Columbia, Vancouver, Canada, Hans Föllmer, Humboldt Universität zu Berlin, Germany, Sebastian Noelle, RWTH Aachen, Germany, Helmut Pottmann, Institute of Discrete Mathematics and Geometry, Vienna University of Technology, Austria
- Jun 11-22: Professor Robert Stein, Michigan State University, USA
- Jun 4-10: Professor Mihai Horoi, Michigan State University, USA
- May 31 - Jun 2: Professor Nouredine Elgaidi, Université de Picardie Jules Verne, Amiens, France
- May 28-31: Professor Rick Falk, Rutgers University, USA
- May 23 - Jun 17: PhD student Chris Malins, University of Sheffield, UK
- May 23-27: Professor Petra Wittbold, Technische Universität Berlin, Germany
- May 22-24: Professor Eitan Tadmor, University of Maryland, USA
- May 19-Jun 1: Professor Jean-Louis Merrien, INSA Rennes, France
- May 9-13: PhD student Juan Martinez Sykora, Instituto de Astrofísica de Canarias, Spain
- May 1-13: Associate Professor Giuseppe Coclite, University of Bari, Italy
- May 1-8: Prof Lin Ping, University of Heidelberg, Germany
- Apr 30 - May 7: Professor Larry Schumaker, Vanderbiit University, Tennessee, USA
- Apr 28 - May 1: Research Director Annalisa Buffa, IMATI-CNR Pavia, Italy
- Apr 20-28: Professor Jörn Frédéric Cottrell, University of Tübingen, Germany
- Apr 3-28: Professor Ming-Jun Lai, University of Georgia, Athens, USA
- Apr 3-25: PhD-student Toure Chérif, University of Orléans, France
- Mar 29 - Apr 2: Professor Sergio Albeverio, University of Bonn, Germany
- Mar 29: CMA workshop (Mathematical Finance for Electricity and Related Markets): Reik Börger, University of Ulm, Germany, Ricardo Green, Lund University, Sweden, Håkon Madsen, Deutsche Bank and Birbeck College London, UK
- Mar 26-30: Professor Alvaro Cartea, Birbeck College, London
- Mar 26-30: Professor Rudiger Kiesel, Ulm University, Germany
- Mar 11-17: Frank Sottile, Technische Universität München/Texas A&M University
- Mar 9-26: Francesca Bisgemi, Munich, Germany
- Mar 10-19: Professor Adimurthi, TIFR Centre, Bangalore, India
- Feb 28 : Mar 2: Carl Lindberg, Chalmers University, Goteborg, Sweden
- Feb 19-25: Boris Andreianov, Université de Franche-Comté, Besançon, France
- Jan 31: Douglas Rogers, University of Hawaii, USA
- Jan 24 - Feb 3: Professor Robert J. Rutten, Sterrekundig Instituut, Utrecht, Netherlands
- Jan 9-10: CMA Workshop (Computational Methods in Astrophysical Problems): Christian Klingenberg, University of Würzburg, Germany, Christian Rohde, University of Freiburg, Germany, Wolfram Schmidt, University of Würzburg, Germany, Raimund Bürger, University of Würzburg, Germany, Robert J. Rutten, University of Hawaii, USA, Helmut Pottmann, Institute of Discrete Mathematics and Geometry, Vienna University of Technology, Austria
7d. Scientific reports, contributions, proceedings etc. (not refereed), published 2006


3. Soomere, Tarmo
4. Øksendal, Bernt
5. Aase, Knut
6. Øksendal, Bernt; Hu, Yaozhong
7. CMA texts for public outreach 2006
10. Soomere, Tarmo. Laevad meie merel: õnnistus või õnnetus (Ship on our sea: blessing or curse).
12. Soomere, Tarmo. Karikas saavutab rannanõlva nõu (a wake from a fast ferry encroaches the coastal slope).
15. Soomere, Tarmo. Laevad meie merel: õnnistus või õnnetus (Ship on our sea: blessing or curse).

APPENDIX 8

TALKS OUTSIDE CMA BY CMA MEMBERS IN 2006

8a. Invited Scientific talks


26. Di Nunno, Giulia. On a version of the fundamental theorem of asset pricing and events of small but positive probability. 1st MAFELAP Conference, Antalya, Turkey, April 26-29, 2006

27. Di Nunno, Giulia. On a version of the fundamental theorem of asset pricing and events of small but positive probability. Guest lecture at La Valle, France, May 12, 2006


33. Eriksen, Hans Kristian Kamfjord. Bayesian foreground analysis of CMB data. Conference "Fundamental Physics with the Cosmic Microwave Background Radiation", UC Irvine, California, USA, March 29-30, 2006


38. Floater, Michael. Spline interpolation, arc length estimation, and divided differences. ACG General Workshop, University of Athens, Greece May 9-11, 2006


43. Hjorth-Jensen, Morten. Basis, model space and wave functions for the shell model. Workshop on Nuclear shell model applications, Michigan State University, USA, February 13-17, 2006

44. Hjorth-Jensen, Morten. From nucleon-nucleon interactions to effective interactions. Workshop on Nuclear shell model applications, Michigan State University, USA, February 13-17, 2006

45. Hjorth-Jensen, Morten. Gamma and Beta decay. Workshop on Nuclear shell model applications, Michigan State University, USA, February 13-17, 2006

46. Hjorth-Jensen, Morten. Nuclear-Nucleon interactions, from QCD to mesonic degrees of freedom. Workshop on Nuclear shell model applications, Michigan State University, USA, February 13-17, 2006

47. Hjorth-Jensen, Morten. Spectroscopic factors. Workshop on Nuclear shell model applications, Michigan State University, USA, February 13-17, 2006


49. Hjorth-Jensen, Morten. Effective Interactions for Weakly Bound Systems and Shell Model Studies. 1st Southern Mediterranean Summer Workshop on Subatomic Physics, University of Tunis El-Manar, Tunisia, May 29 - June 3, 2006


51. Hjorth-Jensen, Morten. Methods for studying weakly bound and unbound nuclei. Workshop at University of Barcelona, Spain, December 1, 2006


55. Holden, Helge. The Abel Prize. With emphasis on Peter Lax. Guest lecture, Penn State University, USA, March 31, 2006


70. Mishra, Siddhartha. Theory and Numerics for conservation laws with discontinuous fluxes, Colloquium, University of Bari, Italy, October 18, 2006

77. Quak, Ewald. The Digital Shape Werkbench Annual Seminar, Wristius, Estonia, October 5-6, 2006.
79. Liny, Ying; Grigolov, Oddbjem; Rouppe, Van Der Voort Luc | Noort, Michel Jan van. Evidence for propagating waves in a viscous fluid Workshop “MHD Waves and oscillations in solar magnetic structures”, Universitat de les Illes Balears, Spain May 29 - June 1, 2006.
8b. Contributed scientific talks, posters etc


2. Dahl, Geir ; Flåtten, Truls ; Foldnes, N ; Gouwela, L . The Jump Formulation for the Hop-Constrained Minimum Spanning Tree Problem The 8th INFORMS Telecommunications Conference, Dallas, USA, March 30 - April 2, 2006


4. Dahl, Geir ; Brualdi, RA . Constructing (0,1)-matrices with given line sums and certain fixed zeros Conference "ILAS 2006", Amsterdam, Netherlands, July 18-21, 2006

5. Dokken, Tor . The GPGPU-project: status and results. Why use the GPGPU? Workshop NTNU Trondheim, Norway, June 8, 2006

6. Fuchs, Franz . Euler's Elasticia and Curvature-Based Inpainting Workshop B7 Numerical Mathematics Circus; Stockholm, Sweden, August 31 - September 1, 2006


9. Hjorth-Jensen, Morten . Experimental and theoretical challenges for the mass in the region $A=6$ to $A=78$ Nuclear Physics seminar, University of Oslo, Norway, September 1, 2006


14. Merken, Knut ; Reimers, Martin ; Schulz, Christian . Computations with the spline control polynomial, Sixth International Conference on Curves and Surfaces; Avignon, France, June 27 - July 5, 2006

15. Orum, Erik ; Leinaas, JM . Myrheim, J . Numerical study of bound entanglement Poster at 38th Symposium on mathematical physics, "Quantum entanglement and geometry", University of Torun, Poland, June 4-7, 2006


17. Guak, Ewald . The Digital Shape Workbench Humboldt-Colloquium, Helsinki, Finland, September 22-24, 2006


20. Rasmussen, Altegeir Flå ; Floater, Michael ; Risebro, Nils Henrik . Reparametrization of surfaces using PDE methods, Sixth International Conference on Curves and Surfaces; Avignon, France, June 27 - July 5, 2006

21. Reimers, Martin ; Merken, Knut . Computing Spline Zeros with Multiplicity Sixth International Conference on Curves and Surfaces; Avignon, France, June 27 - July 5, 2006

22. Morvan, T ; Martin, SF ; Engvold, O ; Roupe, Luc vdV ; Noort, JM . Dynamics of an active region filament: filaments and surges in high resolution Conference "The 38th COSPAR Scientific Assembly", Beijing, P. R. China, July 18-23, 2006

23. Kacher, D ; DiMaio, S ; Samset, Eigil ; Fetics, B ; Nevo, E ; Jolesz, F . Towards MRI-Guided Vascular Intervention with an Electromagnetic Tracking System and 3D Navigation Software Poster at ISMRM, Seattle, USA, May 6-12, 2006

24. Samset, Eigil ; Kacher, D ; Epstein, LM ; Reynolds, GH ; Jolesz, F ; ECG Triggered MRI-Guided Navigation for Cardiac Interventions Poster at ISMRM, Seattle, USA, May 6-12, 2006


26. Risholm, P ; Sauter, AR ; Bosse, G ; Elle, OJ ; Samset, Eigil . Registration free MRI-US fusion for identification of infraclavicular parts of plexus brachialis Poster at 20th International Congress on Computer Assisted Radiology and Surgery, Osaka, Japan, June 28 - July 1, 2006

27. Jolanto-Parmar, A ; Patthyana, P ; Gossens, R ; Freudenthal, A ; Samset, Eigil . De-Ridder, H . Exploring a user centric methodology to investigate and integrate information gathered during medical intervention 16th World Congress on Ergonomics, Maastricht, Netherlands, July 10-14, 2006

28. Samset, Eigil ; Hans, A ; Von Spiczak, J ; DiMaio, S ; Ellis, R ; Hata, N ; Jolesz, F . The SIGN: A dynamic and extensible software framework for Image-Guided Therapy MICCAI workshop on Open Source and Data for Medical Image Computing and Computer-Assisted Intervention, Copenhagen, Denmark, October 1, 2006

29. Schulz, Christian ; Reimers, Martin ; Merken, Knut . Intersection of Spline Curves using knot insertion, Sixth International Conference on Curves and Surfaces; Avignon, France, June 29 - July 5, 2006

30. Soland, Johan ; Dokken, Tor . Real Time Algebraic Surface Visualization Poster on IEEE Conference "SC06", Tampa, Florida, USA, November 11, 2006


32. Soomere, Tarmo . Extreme slopes in interactions of long shallow water waves Workshop of the SEAMOS network, Toulouse, France February 16-17, 2006


34. Soomere, Tarmo . On the possibilities of reducing coastal pollution by a proper choice of the fairway International congress on coastal operational oceanography, Brest, France, October 16-17, 2006

35. Soomere, Tarmo . Trends and extremes of wave conditions in the northern Baltic Sea Workshop SEAMOS, Leuven, Belgium, October 26-28, 2006

36. Soomere, Tarmo . Fast ferry traffic as a new forcing factor of environmental processes in semi-enclosed sea areas” Nordic Marine Science Conference, From the Arctic to the Baltic, Mid-ocean to microbats, Oslo, Norway, November 1-3, 2006


40. Benth, Fred Espen . Prising og sikring av garantier - det teoretiske grunnlaget i et praktisk perspektiv Fagseminar om avkastningsgarant, Den norske aktuforsikring, October 12, 2006


42. Carlsson, Mats . Solen vår nærmeste stjerne Ungforsk, University of Oslo, Norway, September 27, 2006


8c. Talks for general audiences, public outreach


2. Benth, Fred Espen . Prising og sikring av garantier - det teoretiske grunnlaget i et praktisk perspektiv Fagseminar om avkastningsgarant, Den norske aktuforsikring, October 12, 2006


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<th>Appendix 9</th>
<th>Media Appearances 2006</th>
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| 9a. Radio  | 1. NRK P2 “Verdt å vite” (27.11.2006) Hjorth-Jensen, Morten  
2. NRK P2 “Verdt å vite” (27.11.2006) Lindstrøm, Tom Louis. Om differensialligninger og kaos.  
5. Postimees (the leading daily newspaper, Estonia) (10.08.2006). Soomere, Tarmo. Interview in the case of an unusually strong upwelling event along the northern coast of Estonia |