



UiO : **Department of Physics**
University of Oslo

Motivation for physics

Physics colloquia NTNU 26 March 2021

Maria Vetleseter Bøe



IMPEL

Interactive engagement and
motivation in physics learning



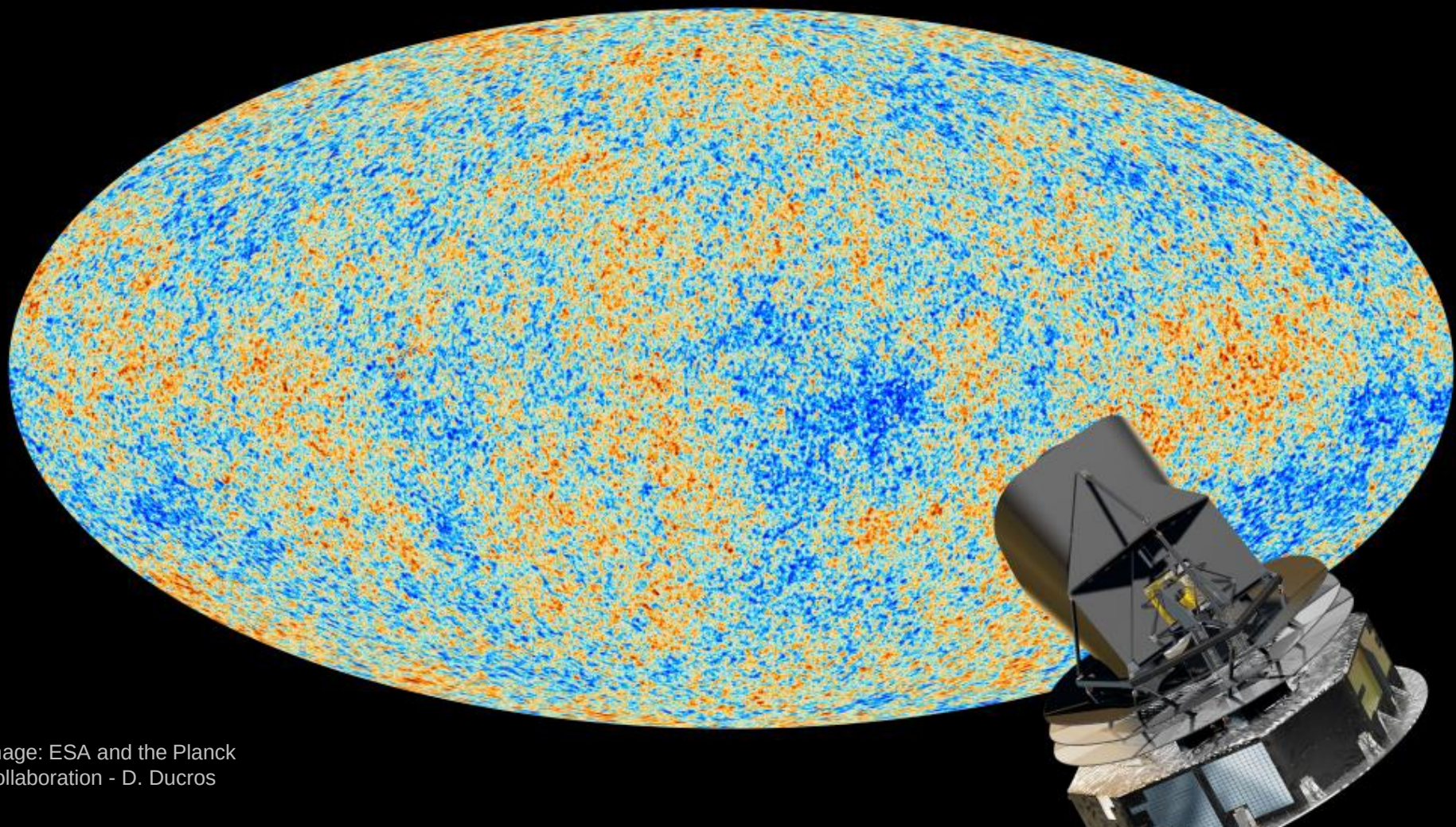


Image: ESA and the Planck
Collaboration - D. Ducros



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What is
motivation?

Why do we
care about
motivation in
physics?

Why do our
students choose
physics?

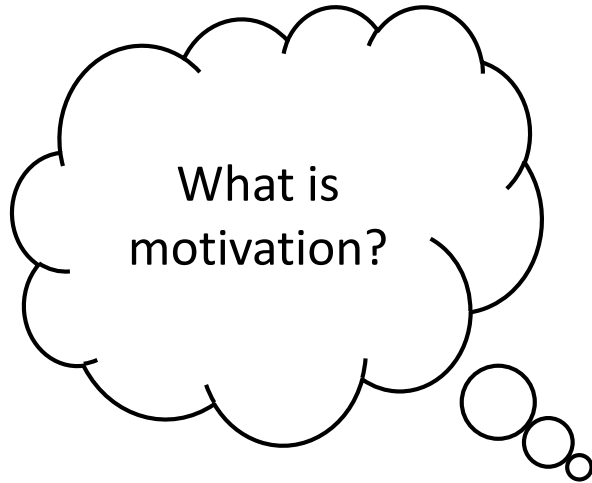
How does our
teaching interact
with their
motivation?

Outline

Micro research

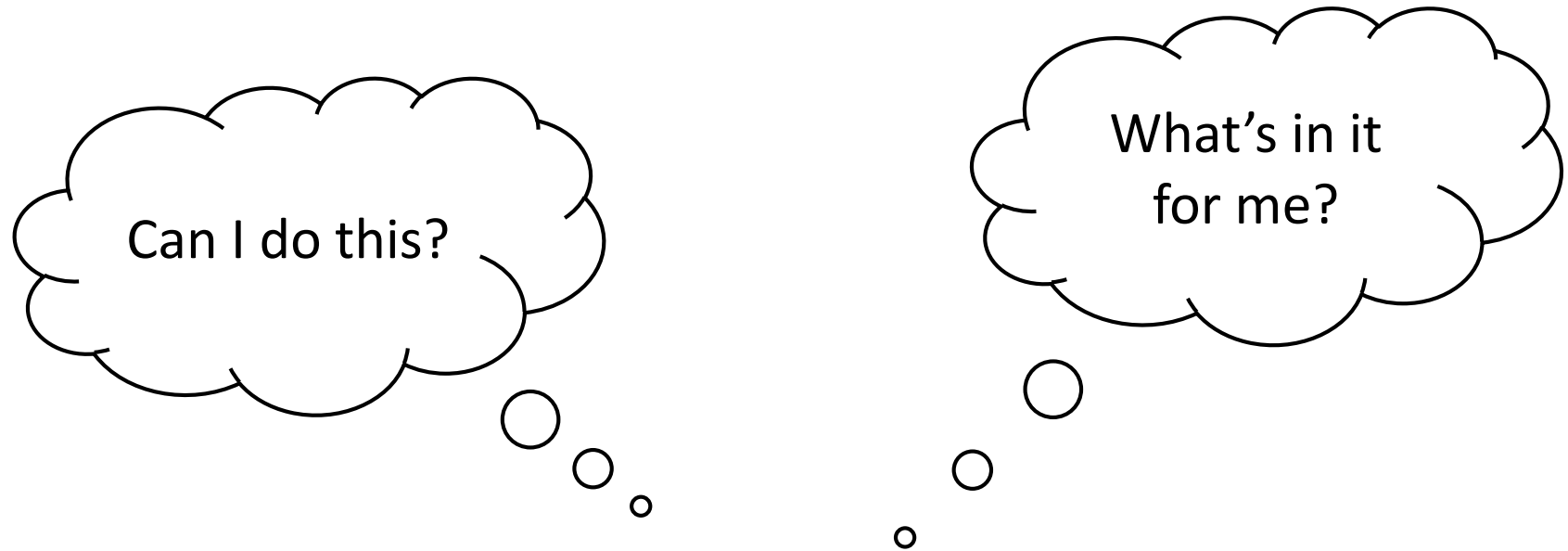
What made you choose your study programme?

- Post in chat

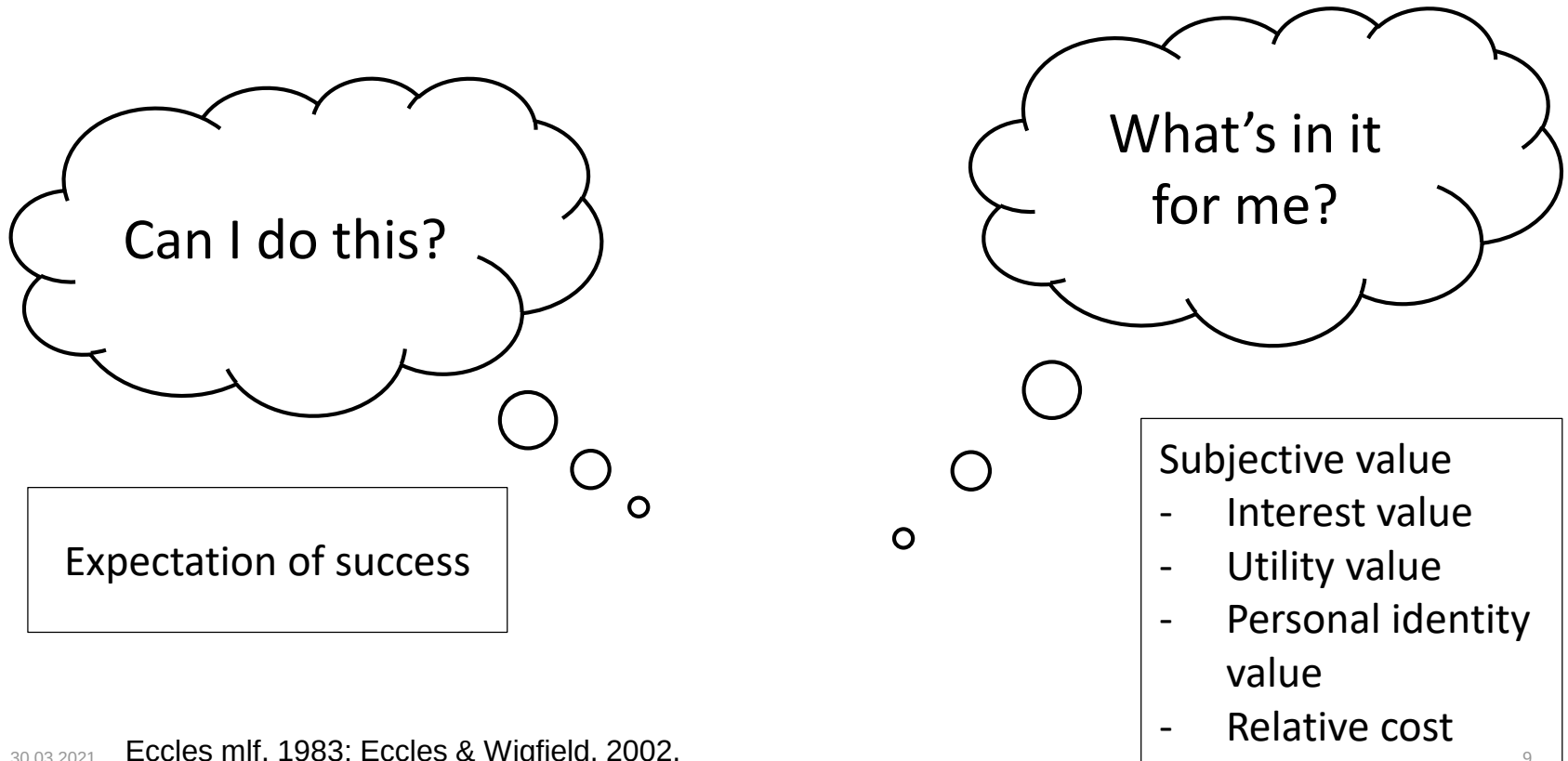


Motivation is what makes us act.

Two important questions in motivation theory



Expectancy-value model of motivation





Intrinsic motivation

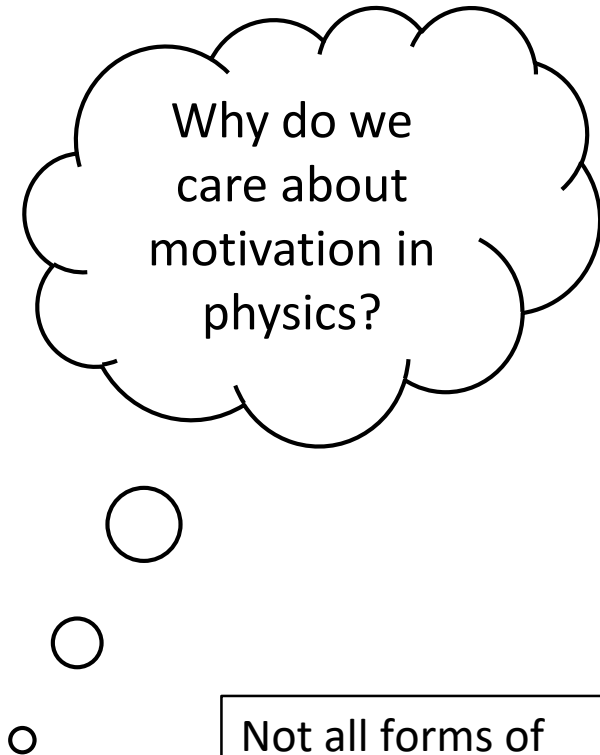
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Promotes learning – Extrinsic motivation – Hinders learning

10

Motivation predicts physics choice, retention, and performance.

(Sawtelle et al., 2012;
Stiles-Clarke & Macleod, 2017)



Why do we care about motivation in physics?

Not all forms of motivation promote learning.

(Deci & Ryan, 2008)

Motivations are dynamic and formed by culture and contexts.

(Deci & Ryan, 2008, Eccles & Wigfield, 2002)

Interest promotes engagement, learning, focus, and perseverance.

(Renninger & Hidi, 2015).

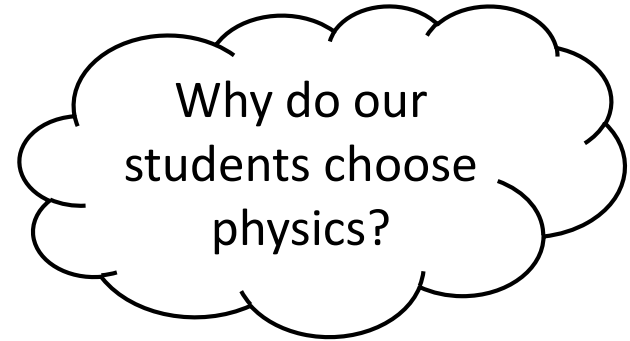


Physics students
tend to be
motivated by
interest and self-
realisation.

(Bøe & Henriksen, 2013;
Lyons & Quinn, 2010;
Hazari et al., 2011, 2017).

Some students are kept
out of physics by
notions of physics being
only for the elite few.

(DeWitt et al., 2018)



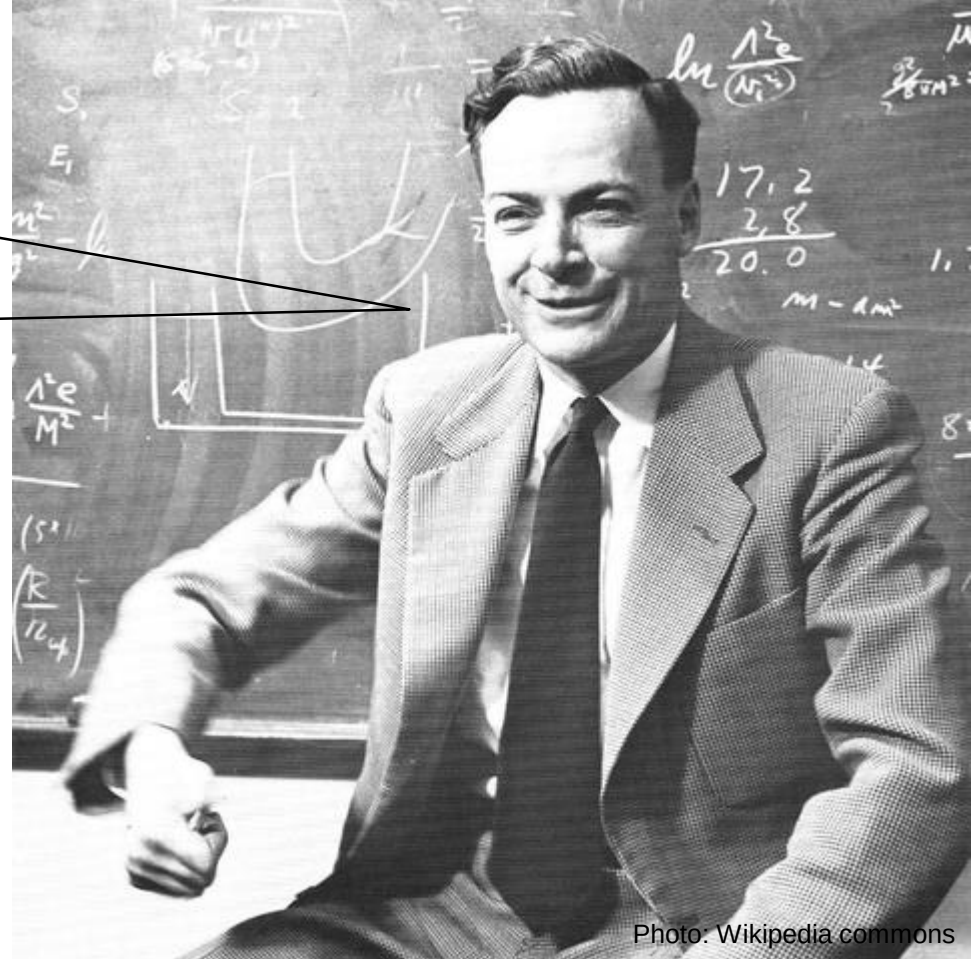
Secondary students, especially,
are also motivated by utility
value for future education and
careers.

(Bøe & Henriksen, 2013; Taylor, 2015).



«Physics is like sex.
Sure, it may have some
practical results,
but that's not why we
do it.»

Richard P. Feynman



(Bøe & Henriksen, 2013):

Many physics students see idealism as important in a future job.





The IMPEL project

- IMPEL researches motivation and teaching in university physics, especially active learning.
- Aims to understand and improve physics education in order to motivate a broad range of students for learning.

Anders Lauvland (PhD student)
Ellen Henriksen (professor)
Tor Ole Odden (post doc)
+ me

Collaborating institutions:
NTNU, UiT, NMBU, and UiB



Results from first data collection study year 19/20

Respondents from NTNU, UiO, UiT, NMBU, and UiB

Study programme	Total	Women	Men
Physics, B.Sc.	107	40	65
Physics, engineering (5 y)	128	64	63
Physics, other	83	39	41
Total	318	143 (45%)	169 (53%)

Motivation for learning physics

25 Likert scale items

1: Completely disagree

5: Completely agree

2. I hvilken grad er du enig i følgende utsagn om fysikkemnene du tar dette semesteret?

	Helt uenig	Delvis uenig	Verken enig eller uenig	Delvis enig	Helt enig
a. Jeg synes det er veldig gøy å lære fysikk.	☐	☐	☐	☐	☐
b. Jeg kan bli så engasjert at jeg glemmer tiden når jeg holder på med fysikk.	☐	☐	☐	☐	☐
c. Fysikk handler om temaer jeg synes er veldig spennende.	☐	☐	☐	☐	☐
d. Jeg er veldig interessert i å lære nye ting i fysikk.	☐	☐	☐	☐	☐
e. Det jeg lærer i fysikk vil gi meg en fordel på arbeidsmarkedet.	☐	☐	☐	☐	☐

Factor analysis → motivation constructs (Eccles et al., 1983; 2002)

Interest value

*«I am very
interested in
learning new things
in physics.»*

Personal identity
value

*«Learning physics is
important to me.»*

Utility value

*«What I learn in
physics is very useful
to me in the future.»*

Relative cost

*«I find studying
physics to be
tiring.»*

Expectation of success

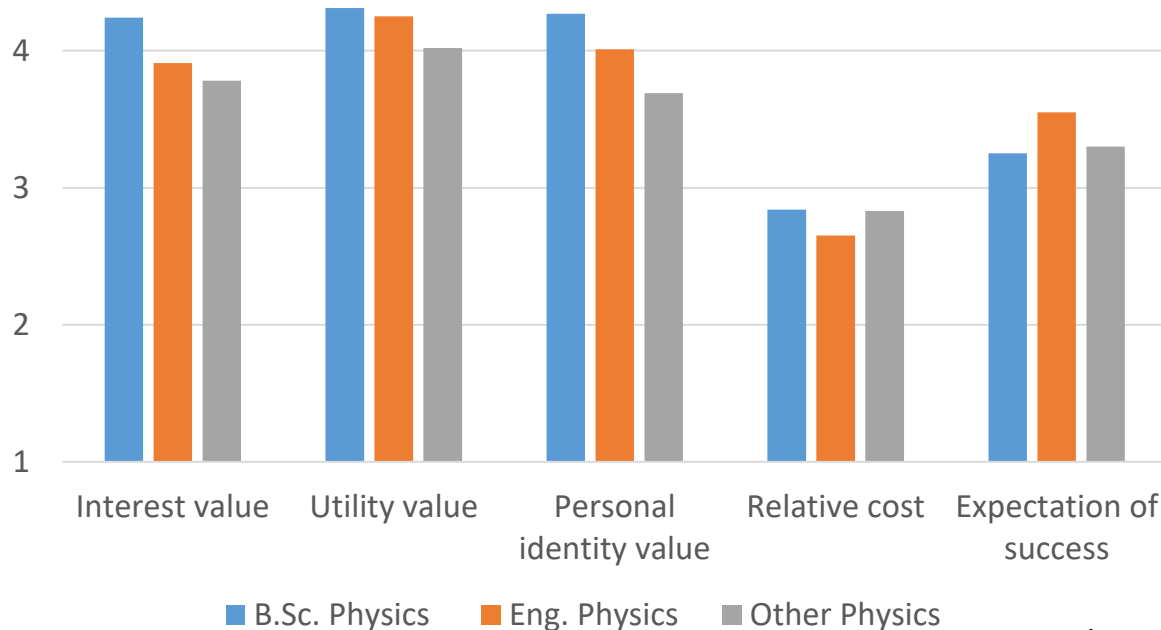
*«I learn the subject matter
easily in the physics classes I
take this semester»*

Motivation for learning physics

B.Sc. higher interest
than Eng.
($d=0,47$, 95% CI)

B.Sc. higher personal value
than Eng.
($d=0,40$, 95% CI)

Women had lower
expectation of
success ($d=0,8$),
lower interest ($d=0,6$),
and higher cost ($d=0,4$)
than men.



Eng. higher exp. of
success than B.Sc.
($d=0,36$, 95% CI)

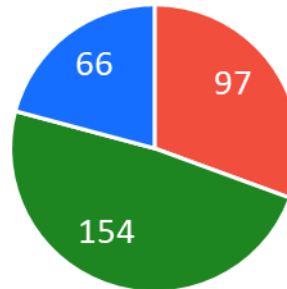
Students grouped into three clusters: motivation profiles



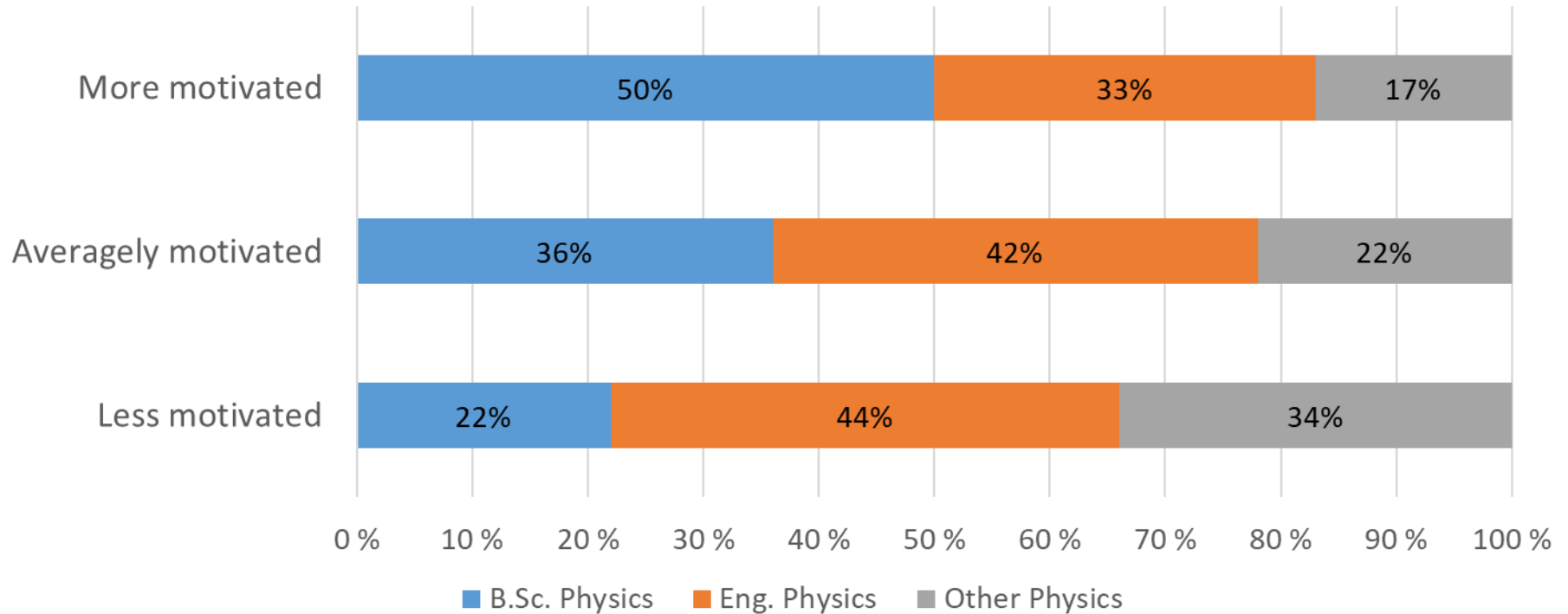
1: Less motivated ($N=97$)

2: Averagely motivated ($N=154$)

3: More motivated ($N=66$)

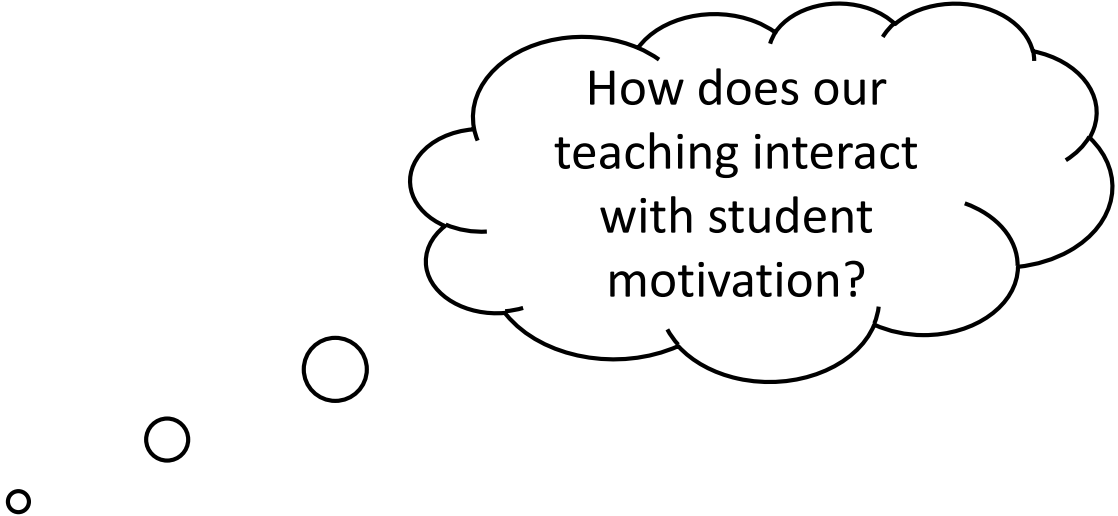


Distribution on study programme



New micro research

- What makes you stay on this zoom talk, why have you not disconnected?
- Post in chat



How does our
teaching interact
with student
motivation?

Active learning works, but students don't necessarily acknowledge it.

Active learning
improves learning
in physics (Fraser et
al., 2014).

Students in active
learning classrooms
learnt more, but they
perceived that they
had learnt less than
students in traditional
classrooms.
(Deslauriers et al., 2018)



Students tend to be motivated by active participation, collaboration, and variation.

(Fraser et al., 2014; Hänze & Berger, 2007)

Gender gap in expectation of success removed after one year of active learning.

(Espinosa et al., 2019)

Interest and expectation of success decreased during first year in active learning classrooms, but social interaction affected expectation of success positively.

(Dou et al., 2018)

Expectation of success decreased during first year, in both traditional and active learning classrooms.

(Nissen & Shemwell, 2016)

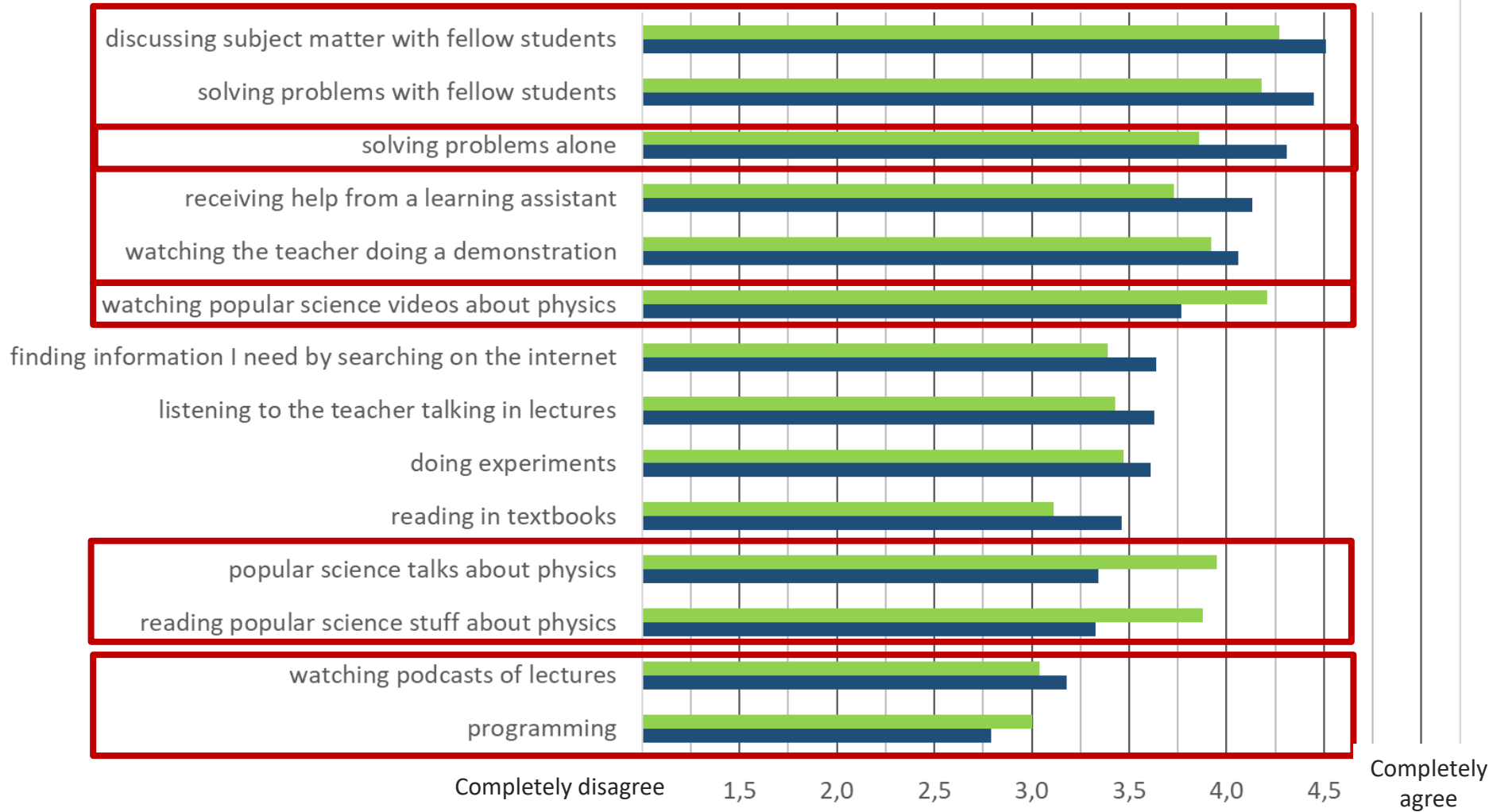
Second part of IMPEL survey – learning activity preferences



Learning activity preferences

■ I am motivated by ...

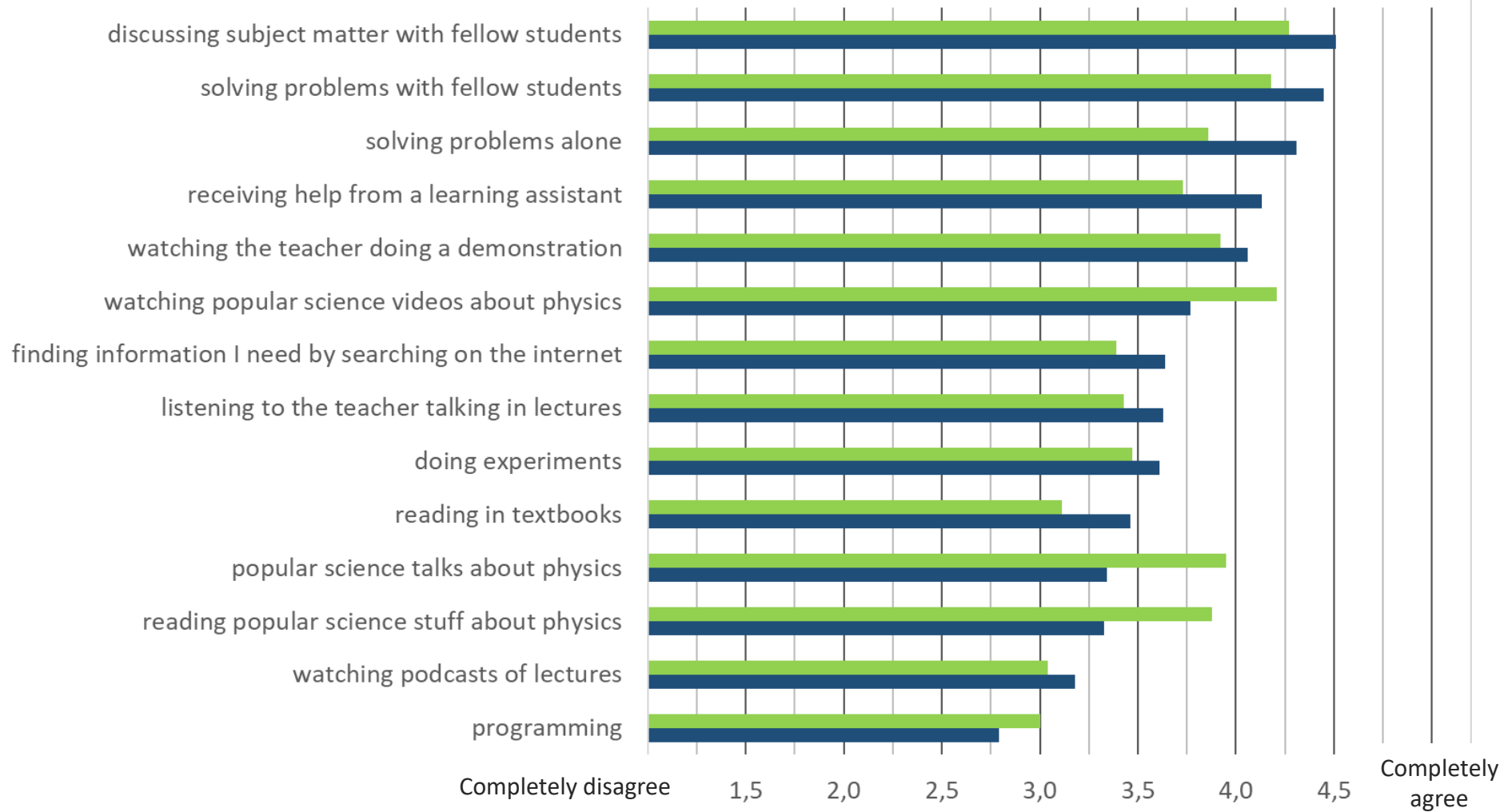
■ I learn physics well by ...



Learning activity preferences

■ I am motivated by ...

■ I learn physics well by ...



IMPEL focus groups:

How can teaching interact with motivation?

4 interviews with 21 students in FYSMEK1110
Mekanikk at UiO January 2020

5 interviews with 20 of the same students in May
2020

Active learning can create mastery experiences and cause intrinsic motivation.

«I experience a lot of mastery in discussions. Or like we talked about, explaining, explaining to others. But discussions in particular, like «yes, yes, ok», then you understand, ok, now I have understood something. [...] I see understanding as the most important, that is what I enjoy, understanding, not just calculating, no, like learn a rule.»

- Focus group participant, UiO



But tasks need to be clear, doable, and given in safe environment.

«What I didn't like much was when some teachers almost forced us to talk too much in lectures, [...] he like explained something that was completely new, and if you are not sitting next to someone you know [...], and then you have nothing to say while the other person has understood abit more. And then you don't know that person enough to like ask your question and then you just sit there like «yes, I agree, totally agree, I understand everything, yes.»»

- Focus group participant, UiO

«It helps that the [in lecture discussion questions] are so specific, I find, we are supposed to reach an answer, like, it is not just «think about what you have understood about this now», it is like «now I will show you what you have understood through this specific question.»

- Focus group participant, UiO

Pandemic experiences:

Loss of structure and social learning harmed motivation.

«I need those, collaboration and I need that discussion, the exciting discussion, to enjoy the subject, I think.»

- Focus group participant, UiO

«I can't separate work and non-work if I don't have two separate places. [...] everything just becomes intertwined and then I feel I haven't done anything and then I lose all that experience of mastery that you get in your everyday life.»

- Focus group participant, UiO

Messages

1 in 3 physics students were among the less motivated.

These students are vulnerable when studies get tough.

(Renninger & Hidi, 2015;
Bandura, 1997)

Many students feel they learn from and are motivated by active learning.

But to motivate, active learning activities have to be clear and in a context that feels safe.

Different motivation profiles are represented in all study programmes, meaning every teacher and classroom have to meet different motivations.

Loss of structure and social learning harmed motivation in lockdown.



Photo: Fredrik Jensen



What is next for the IMPEL project?

New survey data collection in mid April

→ Questionnaire adopted to understand pandemic conditions

Hopefully third round of focus group interviews in Oslo in May

$$\begin{aligned}
\mathcal{L} = & -\frac{1}{2}\partial_\nu g_\mu^a \partial_\nu g_\mu^a - g_c f^{abc} \partial_\mu g_\nu^a g_\mu^b g_\nu^c - \frac{1}{4} g_s^2 f^{abc} f^{ade} g_\mu^b g_\nu^c g_\mu^d g_\nu^e + \frac{1}{2} i g_s^2 (\bar{q}_i^\sigma \gamma^\mu q_j^\sigma) g_\mu^a + \bar{\Theta} \partial^2 \Theta + g_s f^{abc} \partial_\mu \bar{\Theta}^a \bar{\Theta}^b g_\mu^c - \\
& \partial_\nu W_\mu^+ \partial_\nu W_\mu^- - M^2 W_\mu^+ W_\mu^- - \frac{1}{2} \partial_\nu Z_\mu^0 \partial_\nu Z_\mu^0 - \frac{1}{2c_W^2} M^2 Z_\mu^0 Z_\mu^0 - \frac{1}{2} \partial_\mu A_\nu \partial_\mu A_\nu - \frac{1}{2} \partial_\mu H \partial_\mu H - \frac{1}{2} W_\mu^2 H^2 - \partial_\mu \phi^+ \partial_\mu \phi^- - M^2 \phi^+ \phi^- - \\
& \frac{1}{2} \partial_\mu \phi^+ \partial_\mu \phi^0 - \frac{1}{2c_W^2} M \phi^0 \phi^0 - \beta_h \left[\frac{2M^2}{g^2} + \frac{2M}{g} H + \frac{1}{2} (H^2 + \phi^+ \phi^- + 2\phi^+ \phi^0) \right] + \frac{2M^4}{g^2} \alpha_h - i g_{CW} [\partial_\nu Z_\mu^0 (W_\mu^+ W_\nu^- - W_\nu^+ W_\mu^-) - \\
& Z_\nu^0 (W_\mu^+ \partial_\nu W_\mu^- - W_\mu^- \partial_\nu W_\mu^+) + Z_\mu^0 (W_\nu^+ \partial_\nu W_\mu^- - W_\mu^- \partial_\nu W_\nu^+) - i g_{SW} [\partial_\nu A_\mu (W_\mu^+ W_\nu^- - W_\nu^+ W_\mu^-) - A_\nu (W_\mu^+ \partial_\nu W_\mu^- - W_\mu^- \partial_\nu W_\mu^+) + \\
& A_\mu (W_\nu^+ \partial_\nu W_\mu^- - W_\mu^- \partial_\nu W_\nu^+)] - \frac{1}{2} g^2 W_\mu^+ W_\mu^- W_\nu^+ W_\nu^- + \frac{1}{2} g^2 W_\mu^+ W_\nu^- W_\mu^+ W_\nu^- + g^2 c_W^2 (Z_\mu^0 W_\mu^+ Z_\nu^0 W_\nu^- - Z_\mu^0 Z_\mu^0 W_\nu^+ W_\nu^-) + \\
& g^2 s_W^2 (A_\mu W_\mu^+ A_\nu W_\nu^- - A_\mu A_\mu W_\nu^+ W_\nu^-) + g^2 s_W c_W [A_\mu Z_\nu^0 (W_\mu^+ W_\nu^- - W_\nu^+ W_\mu^-) - 2A_\mu Z_\mu^0 W_\nu^+ W_\nu^-] - g_\chi [H^3 + H \phi^+ \phi^0 + 2H \phi^+ \phi^-] - \\
& \frac{1}{8} g^2 \alpha_h [H^4 + (\phi^+)^4 + 4(\phi^+ \phi^-)^2 + 4(\phi^0)^2 \phi^+ \phi^- + 4H^2 \phi^+ \phi^- + 2(\phi^0)^2 H^2] - g M W_\mu^+ W_\mu^- H - \frac{1}{2} g \frac{M}{c_W^2} Z_\mu^0 Z_\mu^0 H - \frac{1}{2} i g [W_\mu^+ (\phi^0 \partial_\mu \phi^- - \phi^- \partial_\mu \phi^0) \\
& - W_\mu^- (\phi^0 \partial_\mu \phi^+ - \phi^+ \partial_\mu \phi^0)] + \frac{1}{2} g [W_\mu^+ (H \partial_\mu \phi^- - \phi^- \partial_\mu H) - W_\mu^- (H \partial_\mu \phi^+ - \phi^+ \partial_\mu H)] + \frac{1}{2} g \frac{1}{c_W} (Z_\mu^0 (H \partial_\mu \phi^0 - \phi^0 \partial_\mu H) - i g \frac{s_W^2}{c_W} M Z_\mu^0 (W_\mu^+ \phi^- \\
& W_\mu^- \phi^+) + i g s_W M A_\mu (W_\mu^+ \phi^- - W_\mu^- \phi^+)) - i g \frac{1}{2c_W} Z_\mu^0 Z_\mu^0 (\phi^+ \phi^- - \phi^- \phi^+) - i g s_W M (\phi^+ \partial_\mu \phi^- - \phi^- \partial_\mu \phi^+) - \frac{1}{4} g^2 W_\mu^+ W_\mu^- [H^2 + (\phi^+)^2 + 2\phi^+ \phi^-] \\
& - \frac{1}{4} g^2 \frac{1}{c_W^2} Z_\mu^0 Z_\mu^0 [H^2 + (\phi^+)^2 + 2(2s_W^2 - 1)^2 \phi^+ \phi^-] - \frac{1}{2} g^2 \frac{s_W^2}{c_W^2} Z_\mu^0 \phi^0 (W_\mu^+ \phi^- + W_\mu^- \phi^+) - \frac{1}{2} i g^2 \frac{s_W^2}{c_W^2} Z_\mu^0 H (W_\mu^+ \phi^- - W_\mu^- \phi^+) + \frac{1}{2} g^2 \frac{1}{c_W^2} Z_\mu^0 Z_\mu^0 [H^2 + \\
& (\phi^+)^2 + 2(2s_W^2 - 1)^2 \phi^+ \phi^-] - \frac{1}{2} g^2 \frac{s_W^2}{c_W^2} Z_\mu^0 \phi^0 (W_\mu^+ \phi^- + W_\mu^- \phi^+) - \frac{1}{2} i g^2 \frac{s_W^2}{c_W^2} Z_\mu^0 H (W_\mu^+ \phi^- - W_\mu^- \phi^+) + \frac{1}{2} g^2 s_W A_\mu \phi^0 (W_\mu^+ \phi^- + W_\mu^- \phi^+) \\
& + \frac{1}{2} i g^2 s_W A_\mu H (W_\mu^+ \phi^- - W_\mu^- \phi^+) - g^2 \frac{s_W}{c_W} (2c_W^2 - 1) Z_\mu^0 A_\mu \phi^+ \phi^- - g s_W A_\mu A_\mu \phi^+ \phi^- - e^\lambda (\gamma \partial + m_e) e^\lambda - \bar{\nu}^\lambda \gamma \partial \nu^\lambda - \bar{u}_j^\lambda (\gamma \partial + m_u) u_j^\lambda \\
& - \bar{d}_j^\lambda (\gamma \partial + m_d) d_j^\lambda + i g s_W A_\mu [-(\bar{e}^\lambda \gamma^\mu e^\lambda) + \frac{2}{3} (\bar{u}_j^\lambda \gamma^\mu u_j^\lambda) - \frac{1}{3} (\bar{d}_j^\lambda \gamma^\mu d_j^\lambda)] + \frac{i g}{2\sqrt{2}} W_\mu^+ [(\bar{\nu}^\lambda \gamma^\mu (1 + \gamma^5) e^\lambda) + (\bar{u}_j^\lambda \gamma^\mu (1 + \gamma^5) C_{\lambda k} d_j^k)] + \frac{i g}{2\sqrt{2}} W_\mu^- [(\bar{e}^\lambda \gamma^\mu (1 + \\
& \gamma^5) \nu^\lambda) + (\bar{d}_j^\lambda \gamma^\mu C_{\lambda k} u_j^k (1 + \gamma^5) u_j^k)] + \frac{i g}{2\sqrt{2}} \frac{m_\mu^2}{M} [-\phi^+ (\bar{\nu}^\lambda (1 - \gamma^5) e^\lambda) + \phi^- (\bar{e}^\lambda (1 + \gamma^5) \nu^\lambda)] - \frac{1}{2} \frac{m_\mu^2}{M} [H (\bar{e}^\lambda e^\lambda) + i \phi^0 (\bar{e}^\lambda \gamma^5 e^\lambda)] + \\
& - \frac{i g}{2M\sqrt{2}} \phi^+ [-m_\mu^2 (\bar{u}_j^\lambda C_{\lambda k} (1 - \gamma^5) d_j^k) + m_\mu^2 (\bar{u}_j^\lambda C_{\lambda k} (1 + \gamma^5) d_j^k)] + \frac{i g}{2M\sqrt{2}} \phi^- [m_\mu^2 (\bar{d}_j^\lambda C_{\lambda k}^+ (1 + \gamma^5) u_j^k) - m_\mu^2 (\bar{d}_j^\lambda C_{\lambda k}^+ (1 - \gamma^5) u_j^k)] - \\
& \frac{3}{2} \frac{m_\mu^2}{M} H (\bar{u}_j^\lambda u_j^\lambda) - \frac{3}{2} \frac{m_\mu^2}{M} H (\bar{d}_j^\lambda d_j^\lambda) + \frac{i g}{2} \frac{m_\mu^2}{M} \phi^0 (\bar{u}_j^\lambda \gamma^5 u_j^\lambda) - \frac{i g}{2} \frac{m_\mu^2}{M} \phi^0 (\bar{d}_j^\lambda \gamma^5 d_j^\lambda) + \bar{X}^+ (\partial^2 - M^2) X^+ + \bar{X}^- (\partial^2 - M^2) X^- + \bar{X}^0 (\partial^2 - \frac{M^2}{c_W^2}) X^0 \\
& + \bar{Y} \partial^2 Y + i g_{CW} W_\mu^+ (\partial_\mu \bar{X}^0 X^- - \partial_\mu \bar{X}^+ X^0) + i g_{SW} W_\mu^+ (\partial_\mu \bar{Y} X^- - \partial_\mu \bar{X}^+ Y) + i g_{CW} W_\mu^- (\partial_\mu \bar{X}^- X^0 - \partial_\mu \bar{X}^0 X^+) + i g_{SW} W_\mu^- (\partial_\mu \bar{X}^- Y - \partial_\mu \bar{Y} X^+) \\
& + i g_{CW} Z_\mu^0 (\partial_\mu \bar{X}^+ X^+ - \partial_\mu \bar{X}^- X^-) + i g_{SW} A_\mu (\partial_\mu \bar{X}^+ X^+ - \partial_\mu \bar{X}^- X^-) - \frac{1}{2} g M [\bar{X}^+ X^+ H + \bar{X}^- X^- H + \bar{X}^0 X^0 H] + \frac{1 - 2c_W^2}{2c_W} i g M [\bar{X}^+ X^0 \phi^+ - \bar{X}^- X^0 \phi^-] \\
& - \frac{1}{2c_W} i g M [\bar{X}^0 X^- \phi^+ - \bar{X}^0 X^+ \phi^-] + i g M s_W [\bar{X}^0 X^- \phi^+ - \bar{X}^0 X^+ \phi^-] + \frac{1}{2} i g M [\bar{X}^+ X^+ \phi^0 - \bar{X}^- X^- \phi^0]
\end{aligned}$$

Thank you!

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