Is beauty leading physics astray?

2017: Hans Peter, Farid, Eirik, Thomas, Jiri, Vojtech, Alberto, Miguel, Dirk, Charles, Pedro, Ivan

2018: Sarah, Jiri, Ivan

2017 panel

https://indico.cern.ch/event/674777/contributions/2760916/attachments/1552668/2440099/Beauty_IPPOG.pdf

1. Platonists (ultimate explanation of the Universe must possess beauty)
2. Sceptics (scientific research has nothing intrinsic to do with beauty)

Paul Dirac:

“it is more important to have beauty in one’s equations than to have them fit experiment”

Gian Giudice: When you stumble on a beautiful theory you have the same emotional reaction that you feel in front of a piece of art.

Steven Weinberg: “The horse breeder looks at a horse and says ‘That’s a beautiful horse.’ While he may be expressing an aesthetic emotion, I think he knows that that’s the kind of horse that wins races.”

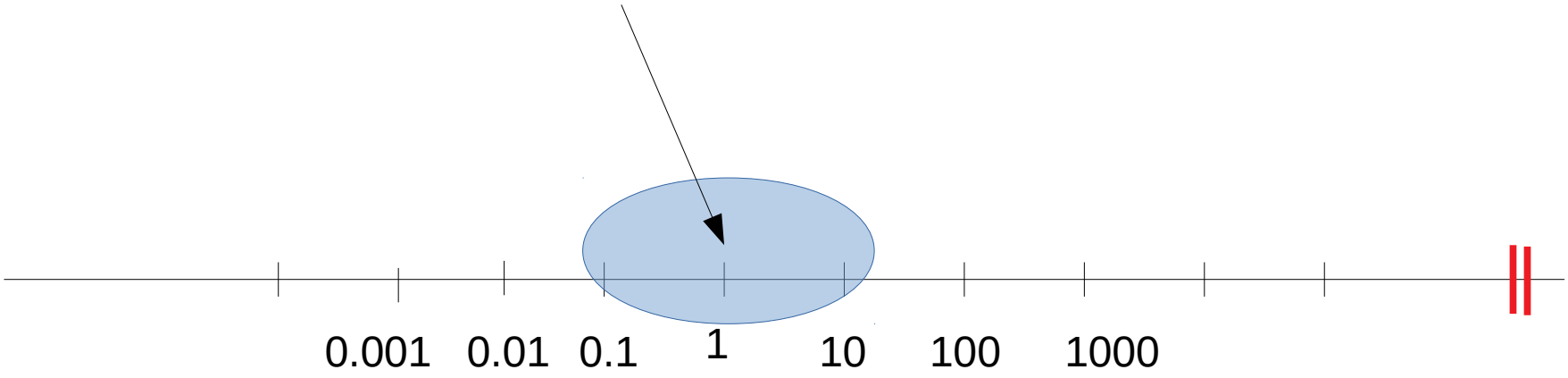
Frank Wilczek: “having tasted beauty at the heart of the world, we hunger for more. In this quest, I think, there is no more promising guide than beauty itself.”

Definition of beauty

Two criteria suggested by Frank Wilczek:

1. Productivity (Simplicity)
2. Symmetry
3. Naturalness

Naturalness



$M_H^2 = M_0^2 + M_1^2$

126 GeV

?

10^{19} GeV

Sabine Hosenfelder: Lost in Math

How beauty leads physics astray

Fermilab physicist Dan Hooper: "To many scientists, the ideas behind supersymmetry are simply too beautiful and too elegant not to be part of our universe. They solve too many problems and fit into our world too naturally."

Maria Spiropulu and Joseph Lykken: "it is not an exaggeration to say that most of the world's particlephysicists believe that supersymmetry must be true"

In his 2001 book, Gordon Kane described supersymmetry as "wonderful, beautiful, and unique," and he showed himself confident that the LHC would discover superpartners.

Michael Peskin: susy is "the next step up toward the ultimate view of the world, where we make everything symmetric and beautiful."

David Gross calls it "beautiful and 'natural' and unique" and believes that "Einstein would, if he had studied [supersymmetry], have loved it."

When I ask Gian Giudice what he makes of the recent LHC data, he says: “We are so confused.”

“Am I worried? I don’t know. I’m confused,” says Michael Kramer, “I’m honestly confused. Before the LHC, I thought something must happen. But now? I’m confused.”

“It is not time to be desperate yet... but maybe it is time for depression already,” remarked the Italian physicist Guido Altarelli in 2011.

Ben Allanach, from the University of Cambridge, has described his reaction to a 2015 analysis of LHC data as “a bit depressing for a supersymmetry theorist like me.”

Jonathan Ellis, a theorist at CERN, has referred to the possibility that the LHC would find nothing but the Higgs boson as “the real five-star disaster.”

Sabine Hosenfelder: The name that has stuck, however, is “the nightmare scenario.” We’re now living this nightmare.

In a 2008 paper, Giudice explained: “The concept of naturalness... developed through

a ‘collective motion’ of the community which increasingly emphasized their relevance

to the existence of physics beyond the Standard Model.”

“In hindsight, it is surprising how much emphasis was put on this naturalness argument,” says Michael Kramer from Aachen. “If I look back, people repeated the same argument, again and again, not really reflecting on it. It is really surprising that this was the main driver for so much of model building. Looking back, I find this strange. I still think naturalness is appealing, but I’m not convinced anymore that this points to new physics at the LHC.”

Nima Arkani Hamed: “Naturalness wasn’t—shouldn’t have been—the argument for the LHC. To the credit of CERN, this argument came from theorists.

Nima abandoned natural beauty 12 years ago in favor of a new idea called “split susy,” a variant of supersymmetry in which some of the expected susy partners are naturally so heavy that they are beyond the reach of the LHC. But split susy then requires fine-tuning to get the observed mass of the Higgs right.

About the reaction of his colleagues to fine-tuning the theory, Nima recalls: “I have been literally yelled at by people at conferences. It’s never happened to me before or since.”

So that, I think, is what happens if you don’t meet the beauty standard of the day.

Hosenfelder: Naturalness arguments are widely believed to be mathematical but they are aesthetic

3 examples of naturalness: Higgs mass, CC, the Strong CP problem - all are not real math inconsistencies, just aesthetic problems

3 examples of real math inconsistencies:

special relativity + Newtonian gravity -> general relativity,

special relativity + QM -> QFT

breakdown of unitarity in SM -> LHC must find new physics (Higgs)

Why does it matter?

Because naturalness

1. made us believe in SUSY
2. made us believe that LHC will see new physics beyond SM
3. made us believe in WIMPS and axions as dark matter
4. was used for 30 years to judge the promise of theories

Thomas Naumann’s comments

I read Hossenfelder's book and tried to get her as my co-speaker at a symposium on Art&Science on Sept 14/15 in Berlin

She gives a good overview what eminent physicists think about truth and beauty. What I do not like is that she generalizes her private frustration to a general pessimism on particle physics without giving alternatives.

I consider it natural that following the Standard Model 'beautiful' theories were developed like Grand Unification, Supersymmetry, Superstrings and Extra Dimensions. It is not our fault that the cost and life

cycles of experiments increased so much so that a theory congestion developed. It took 100 and 50 years to find gravitational waves and the Higgs! Beautiful predictions which were difficult to verify.

Thomas’s comments cont’d

1. There is not only beautiful truth. There may be ugly truth:

1.1 Kepler let Nature speak through observation and data. He broke the ideal symmetry of circular planetary orbits and went to 'ugly' ellipses.

1.2 Beauty is indeed in the eye of the beholder. Schrödinger and Heisenberg loved their own theories but found each other's ugly. Finally, both are true.

1.3 Quantum mechanical entanglement: Einstein never liked it. But Nature seems to have chosen it. One may call it an ugly truth.

2. Beauty can be treacherous and misguide us. Here are some examples:

2.1 Einstein often found his ideas 'too beautiful not to be true':
With general relativity he was lucky to be right with his aesthetic prejudice. However, he admired Hermann Weyl’s attempts
to unify gravity and electromagnetism In this case they were misguided by beauty, although the gauge principle came out of Weyl's efforts.

2.2 Many great theoretical physicists were idealists and Platonists. They made their discoveries when very young (Heisenberg 21, Einstein 26, Dirac 26, ...) but for the many following decades of their life mainly followed their aesthetic ideals which was fruitless.

So following aesthetic ideals can but needs not guide us to the truth. Experimentalists are more directly guided by Nature.

Summary of our panel

Should we communicate to people this state of the field? Our beauty ideals? Our confusion?

Well, even if we did not see anything beyond the Higgs, it makes everything even more interesting

Is the nature truly beautiful in its foundation but right now is hiding it from us?

Or is simplicity an artefact of our times and there is a place for ugly (complex) solutions?