

The Oskar Klein Center – How did it start?

Pre-history, history, post-history

Lars Bergström

Professor emeritus, OKC

Pre-history, about my own career:

PhD in theoretical physics from the Royal Institute of Technology (KTH) in 1981

CERN Fellow 1981- 83

Researcher at Stockholm University (SU) 1983-1992

National Research Council position in Astroparticle physics 1992-1998, SU

Professor, SU 1999 - , *emeritus* since 2019

At CERN, various particle physics calculations, mainly related to quarkonium (mentors, among others, J.D Jackson and John S. Bell).

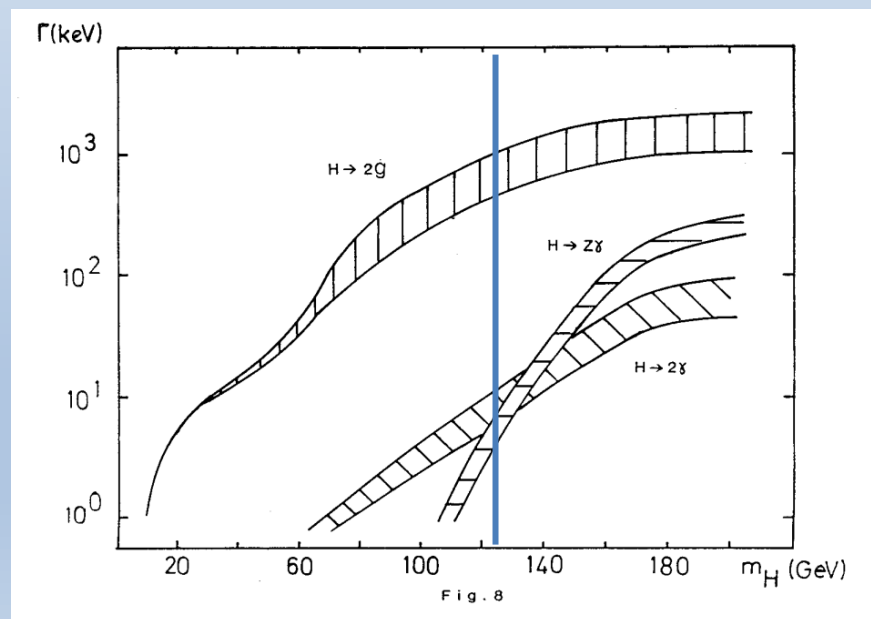
Coming back to Stockholm, I did some work (with PhD student Göran Hulth) on Higgs physics, in particular the loop induced decay $H \rightarrow Z + \gamma$:

This was more than 25 yrs before the discovery of the Higgs. We were early to consider that the Higgs could be heavier than the Z, and pointed out that **new virtual particles** may contribute.

($m_H = 10$ GeV was a popular guess at the time.)

But where and when could this process be studied?

SSC was being built, but cancelled in 1993, the LEP-ring was being built (finished in 1989), LHC was only vaguely conceived (it got colliding beams in 2008).



L. Bergström and G. Hulth, Nucl.Phys.B 259 (1985) 137
Loop-induced process calculated by hand (brute force!).

So, it seemed it would take **some 30 years from 1985** for $H \rightarrow Z + \gamma$ to be measured – waiting for something like the LHC to be built, to eventually finding the Higgs, and > 10 years of running.

What to do in the mean time?

Around 1986, I found a very interesting field of science, which combines knowledge of particle physics with astrophysics and cosmology – **Cosmology and Particle Astrophysics**. The first paper was on supersymmetric dark matter:

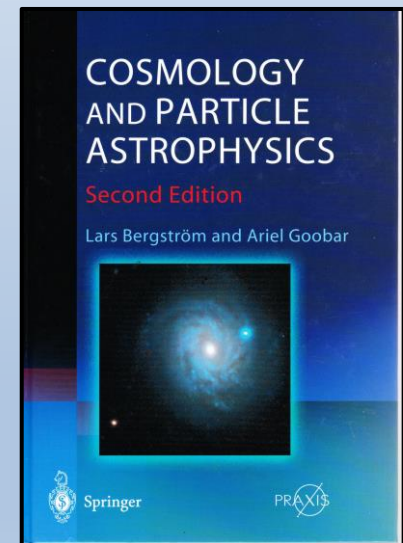
Observable Monochromatic Photons From Cosmic Photino Annihilation,
L. Bergström (Stockholm U.), H. Snellman (Royal Inst. Tech., Stockholm).
Published in: *Phys.Rev.D* 37 (1988) 3737-3741.

This led to our involvement over the next decade, with i.a., Per Carlson, Staffan Carius and Roland Svensson († 2003), in **Fermi-LAT** and other instruments where dark matter could be searched for:

PAMELA (Mark Pearce), LHC, **AMANDA** -> **IceCube** (P.O. Hulth, († 2015),)...

And in 1998 we wrote the **textbook with Ariel Goobar** who was involved in the (later Nobel Prize-winning) Supernova Cosmology Project at Berkeley.

We also developed the **DarkSUSY** code for **a general Particle Dark Matter candidate** (with Paolo Gondolo, Piero Ullio, Joakim Edsjö, Mia Schelke and later Torsten Bringmann).



In the first years of the new millennium, we had started cosmology and particle astrophysics as a new field in Sweden. We were helped by moving into the new building Albanova, so that astronomy and physics of both KTH and SU were now co-located.

We thus had an exciting field of science, and we were a strong group of people.

Now, could we find sources of funding for our new activity?

A new national funding agency, **Vetenskapsrådet (VR)**, (The Swedish Research Council) had been created in 2001 – replacing a number of small disjoint agencies (among them NFR).

The new agency had a large budget, and was within a couple of years announcing substantial collaborative grants. In 2005 we received a large grant (22 MSEK over 6 years) for "High Energy Astrophysics and Cosmology" (HEAC).



Claes Fransson from Astronomy was the PI with **Ariel Goobar, Mark Pearce, Claes-Ingvar Björnsson and myself** co-investigators. As we wanted to build the field bottom-up, the funds were mainly used for financing PhD students. We hired many excellent students, like: **Anders Jerkstrand, Angela Adamo, Pat Scott, Sofia Sivertsson,...**

2005:

HEAC-High Energy Astrophysics and Cosmology Excellence grant, Dept of Physics & Dept of Astronomy, Stockholm University, 2005-2011, for PhD students.

Mentor: **Hector Rubinstein** (1933-2009), Uppsala & Stockholm University.

Pioneer in bootstrap models and string theory, creator of JHEP and JCAP journals.

Hector was very supportive when we, with [Per Carlson](#), [PO Hulth](#), [Bengt Gustafsson](#), [Claes Fransson](#) among others developed the experimental field of astroparticle physics in Sweden, through the PAN (Particle Astrophysics in the North) project in 1991.

PAN → AMANDA → IceCube. Hector was a great supporter of astroparticle physics, also the later projects, e.g. the Fermi satellite, and the Supernova Cosmology Project (from which [Ariel Goobar](#) came). **He was instrumental in making seminars and colloquia a regular part of our working week.**



Gabriele Veneziano
gave the 2007 Oskar Klein
Lecture at Stockholm University

In 2007, after the national research budget had been raised in several steps, VR announced substantial 10-year grants. As this was coinciding with the 300-year anniversary of the birth of the great botanist, Carl von Linné (Linnaeus in latin), these grants were called Linnaeus grants. We applied as "The Cosmoparticle Collaboration" (CPC), but changed the name to "**The Oskar Klein Centre**" (OKC), after consulting with living relatives of Oskar Klein, once our application was approved. (In 2007, Nordita also moved to Sweden, with many opportunities of collaboration.)



Oskar Klein, 1894 – 1977

PhD Stockholm 1921

Assistant with Niels Bohr, Copenhagen
1921-22

Instructor, Ann Arbor, Michigan, 1922-25

Lecturer Copenhagen 1926-30

Professor Stockholm University 1931-1962

Kaluza-Klein model, Klein paradox, Klein-Gordon equation, Klein-Nishina formula, Klein-Jordan quantization, Rydberg-Klein-Rees method for diatomic molecules, Klein's lemma for entropy, Spin-1 bosons for weak interactions, Alfvén-Klein cosmology,...



The 10 people signing the proposal

L. Bergström (PI) CoPS, Fysikum, SU

C. Fransson (Co-PI), Astronomy, SU

J. Edsjö, CoPS, Fysikum, SU

A. Goobar, CoPS, Fysikum, SU

J. Sollerman, Astronomy, SU

G. Östlin, Astronomy, SU

K. Jon-And, Particle Physics, SU (CERN-ATLAS)

S. Hellman, Particle Physics, SU (CERN-ATLAS)

K. Hultqvist, Particle Physics, SU (IceCube)

M. Pearce, Physics, KTH

Representing ~ 80 people: Faculty (25), Research assistants (5), Postdocs (10) and Graduate Students (40) at SU and KTH

The Swedish Research Council (VR), June 2008, and the birth of OKC:

[Linnaeus grant](#), 70 MSEK over 10 years (from July 1, 2008) granted for the project "The Oskar Klein Centre of Cosmo Particle Physics" at Stockholm Univ. After a successful review after 2 years, the sum was increased.

Most of the funds were used to hire postdocs (10 at the first announcement), and after a few years one assistant professor, **Stephan Rosswog**

Some other fields of Linnaeus grants in Sweden related to physics & astronomy:

Engineered Quantum Systems
Novel Functional Materials
Multidisciplinary Laser Spectroscopy
Nanoscience and Quantum Engineering
Climate evolution, variability and sensitivity
Advanced optics and photonics, ...



[The final evaluation report](#), in 2020, concluded:

[The top three Centres \(of 12 in natural sciences\)](#) were found to be: Insect Ecology (SLU), Engineered Quantum Systems (Chalmers), [Oskar Klein Centre for Cosmoparticle Physics \(OKC\)](#) of Stockholm University

Who were our first postdocs, *OKC Fellows*, and where did they go?

Chad Finley (M) - Wisconsin, USA → OKC → Professor, Stockholm University

Josefin Larsson (F) - Cambridge, UK → OKC → Professor, Royal Inst. Tech. (KTH) Stockholm

Are Raklev (M) - Cambridge, UK → OKC → Professor, Oslo

Kanan Datta (M) - IIT Kharagpur, India → OKC → Professor, Presidency Univ., Kolkata

Rachel A Rosen (F) - NYU, USA → OKC → Professor, Carnegie Mellon U.,

Antje Putze (F) – Grenoble, France → OKC → 4-yr position in Aachen → industry (Deepomatic, France)

Zhaoyu Yang (F) - Ottawa, Canada → OKC → Senior postdoc at Ohio SU → industry (NYC?)

Alessandro Cuoco (M) - Aarhus, Denmark → OKC → Professor, Torino U.

Martin Sahlén (M) - Sussex, UK → OKC → Researcher, Uppsala U.

Chris Savage (M) - Minnesota, USA → OKC → Postdoc Utah, USA → 2016 left physics for architecture (!)

Follow-up, 2023, at 15-year anniversary:

OKC not only survives, it is as strong as ever!

Katie Freese was 2014 granted a ten-year grant of 10 MSEK/year (i.e., larger than the full OKC grant) from VR and has employed an excellent group of PhD students and postdocs.

In 2016, **Frank Wilczek** received a similar grant (for condensed matter and astroparticles, axions)

I was replaced at OKC in 2015 by **Ariel Goobar**, who led OKC until mid 2016, when **Hiranya Peiris** took over as new OKC director, and among other things led the new Vera C. Rubin (LSST) activity.

From last year, **Ariel** is again leading OKC. The Vera C. Rubin Observatory expects first light end of 2024.

The steady stream of large grants (**K&A Wallenberg and VR**) continues. Big grants have, e.g., been obtained by Jan Conrad, Hiranya Peiris, Josefin Larsson, Ariel Goobar, Tim Linden,... Actually, after taking over much of the floor space in sections of AlbaNova, we are close to the physical limit of the building. Fortunately, new buildings are just being ready North of AlbaNova.

When OKC started, we had **80 people** involved (including PhD students and postdocs). 15 years later, I count **150 names belonging to OKC**.



Oskar Klein Centre meetings

Beyond the Standard Model Working Group	101 events	
Cosmology and Gravitation Working Group	145 events	
Extreme Objects Working Group	102 events	
Theory Working Group	47 events	
Other OKC meetings	8 events	
OKC colloquia	453 events	
Theoretical Cosmology Journal Club	20 events	
Galaxy Formation and Evolution Journal Club	3 events	
Machine Learning Journal Club	14 events	
Kilonova Journal Club	4 events	
Axion Journal Club	1 event	




Managers

- Joakim Edsjö
- Siska De Baerdemaeker
- Sten Hellman

Footnote: A month ago, on [Sept. 8, 2023](#), the first detection of the $H \rightarrow Z + \gamma$ decay was finally announced, [38 years after](#) our paper, in joint work of ATLAS and CMS at CERN's LHC.

The result is around [2 sigma larger](#) than that of the Standard Model, may get to 5 sigma precision with High Luminosity LHC runs in the next few years. [Interesting!](#)

EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)

Submitted to: Phys. Rev. Lett. CERN-EP-2023-114
September 8, 2023

Evidence for the Higgs boson decay to a Z boson and a photon at the LHC

The ATLAS and CMS Collaborations

The first evidence for the Higgs boson decay to a Z boson and a photon is presented, with a statistical significance of 3.4 standard deviations. The result is derived from a combined

[hep-ex] 7 Sep 2023

Posthistory, 2024-

An important new phase emanating from OKC:

Congratulations to Ariel Goobar, Jon Gudmunsson, Tim Linden, Hiranya Peiris, Christian Ohm, Sara Strandberg, Jens Jasche, and Christophe Clement of OKC for winning **SEK 30 million in 5-year grant 2024-2028**.

EDUCATE (Excellence Dark Universe Centre and Technology Enabler) aims to unravel the mysteries of dark matter and dark energy, focusing on building sensitive particle detectors, conducting groundbreaking astronomical observations and developing advanced data analysis techniques.

The center also plans to establish a dedicated doctoral program branch for training students and fostering collaboration with the industry.



Keep up the good speed!
I will now enjoy from the
spectator section!



The End