

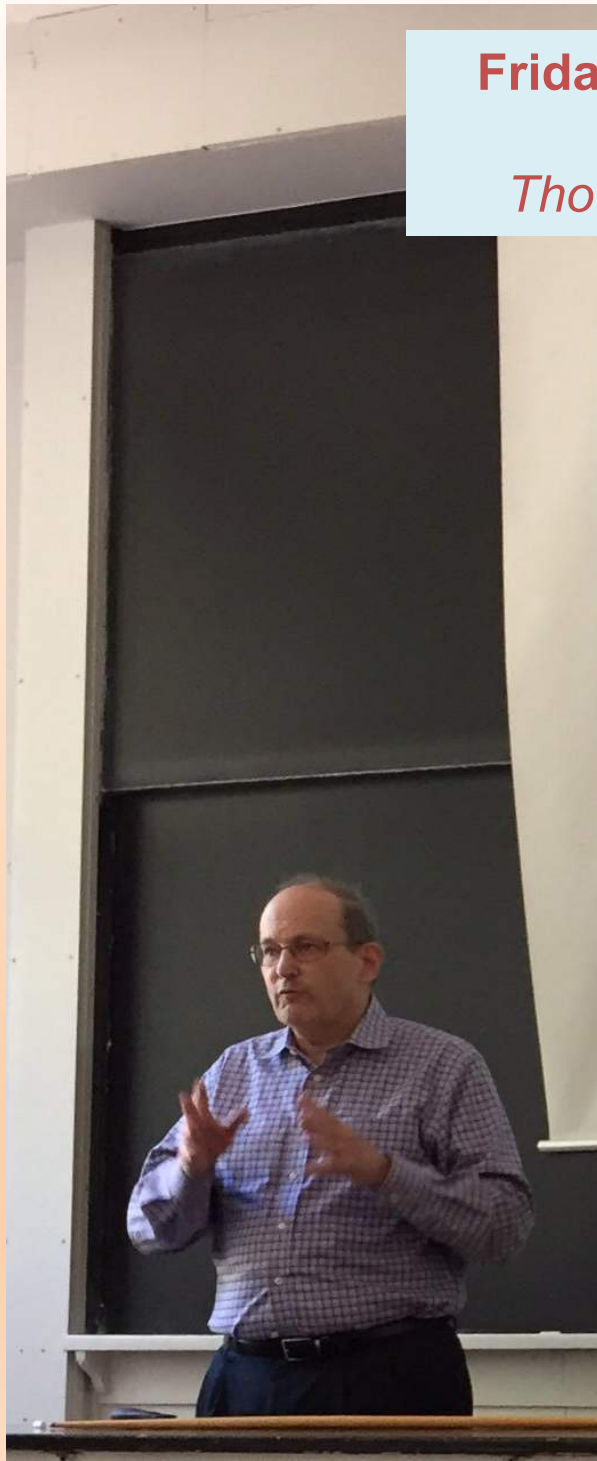
welcome to the Niels Bohr Institute



*“The task of having to introduce a constantly number of young people into the results & methods of modern science ... Through the contributions of the young people themselves new ideas are constantly introduced into the work”*


**Niels Bohr, 3 March 1921**

Friday, May 26 2017 at 1:30 pm in Aud A  
Paul Steinhardt (Princeton)  
*Thoughts on self-interacting dark matter*



Can we rule this idea out?  
Self-Interacting Dark Matter (SIDM)  
D. Spergel & PJS (1999)

Dumbest SIDM model:



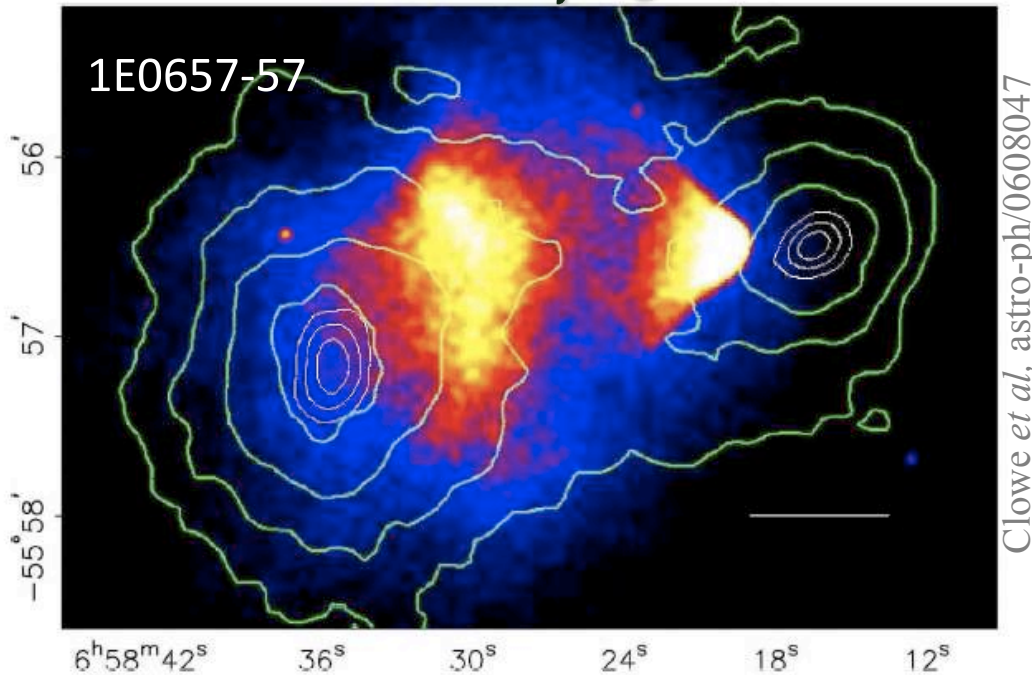
$\sigma/m = O(1) \text{ cm}^2/\text{g}$   
or  $O(1) \text{ barn}/\text{GeV}$

### Observational Evidence for Self-Interacting Cold Dark Matter

David N. Spergel and Paul J. Steinhardt  
*Princeton University, Princeton, New Jersey 08544*  
(Received 20 September 1999)

Cosmological models with cold dark matter composed of weakly interacting particles predict overly dense cores in the centers of galaxies and clusters and an overly large number of halos within the Local Group compared to actual observations. We propose that the conflict can be resolved if the cold dark matter particles are self-interacting with a large scattering cross section but negligible annihilation or dissipation. In this scenario, astronomical observations may enable us to study dark matter properties that are inaccessible in the laboratory.

# What can astrophysics tell us about dark matter interactions?



The 'Bullet Cluster' is often cited as evidence that dark matter is *collisionless* ... in actual fact it sets a rather *weak* limit on DM self-interactions:  $\sigma \lesssim 10^{-24} \text{ cm}^2/\text{GeV}$

Moreover it poses a challenge for  $\Lambda$ CDM cosmology: ... would expect to see only  $\sim 0.1$  such systems up to  $z = 0.3$  but many more colliding clusters have been found (Kraljic et al, 1412.7719)

But in Abell 3827, the dark matter halo of N1 appears to be displaced by  $1.6 \pm 0.48$  kpc from its stars implying that DM is self-interacting with:  $\sigma \sim 1.5-3 \times 10^{-24} \text{ cm}^2/\text{GeV}$ !

If true would rule out most candidates for dark matter (axions, neutralinos, sterile neutrinos ...)

Such a separation is sensitive to whether the self-interactions are contact or long-range (Frandsen et al, 1308.3419, Kahlhoefer et al, 1504.06576) so gravitational lensing can discriminate between particle candidates for dark matter!



cosmo-nordita... Self-interacting... Current Theme... DAVCo « CP³... ATLAS Standar... KITP Probing funda... The High Energ... Home | IceCub... **Login**

Europe/Copenhagen English



The Niels Bohr International Academy

## Self-interacting dark matter

from July 31, 2017 to August 4,

2017 (Europe/Copenhagen)  
Niels Bohr Institute  
Europe/Copenhagen timezone

Overview

- Timetable & Lecture Materials
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- List of registrants
- Accommodation
- Practical information
- Out & About

Enquiries to

✉ studsgaard@nbi.ku.dk



Starts Jul 31, 2017 09:15  
Ends Aug 4, 2017 22:00  
Europe/Copenhagen

Niels Bohr Institute  
Auditorium A  
Blegdamsvej 17  
2100 Copenhagen  
Denmark

Prof. Sarkar, Subir  
Bringmann, Torsten  
Dr. Kahlhoefer, Felix  
Schmidt-Hoberg, Kai

### Aims and Format

This workshop will bring together astronomers and particle physicists interested in the phenomenology of self-interacting dark matter. This is a meeting for experts so *participation is by invitation only*. All invited participants will be provided local hospitality. If you are particularly interested in participating, then *please contact the organisers*.

There will be two themes explored every day - one in the morning and one in the afternoon. In each, a keynote talk will be followed by brief contributions. It is intended that discussion should take up most of the time.

- Standard structure formation in  $\Lambda$ CDM: successes & failures (Pontzen & Yu)
- Gravitational lensing probes SIDM (Carvalho)
- Structure formation with SIDM: theory (Cyr-Racine)
- Structure formation with SIDM: simulations (Zavala)
- SIDM particle model building (Zaldivar)
- Constraints on SIDM from direct & indirect detection (Tulin)
- Small-scale structure beyond SIDM (Archidiacono)
- Summary & future directions (Boehm)

If you wish to make a brief contribution then please contact the relevant session convenor(s) named above.

Participants are expected to arrive on Sunday and stay until the following Saturday. There will be a **welcome reception** on Monday and the **workshop dinner** on Friday, while on Wednesday there will be an **all-day excursion** to the Louisiana Museum of Modern Art where discussions can continue in an informal setting.

This meeting is supported by a Niels Bohr Professorship grant awarded by the Danish National Research Foundation and is hosted by the NBIA Astroparticle Physics Group.

Administrative Coordinator: Anette Luff Studsgård



42 participants (from 13 countries)



Niels Bohr Institute



The Niels Bohr  
International Academy

NIELS BOHR ARCHIVE

Aud A, B, C ...  
Lounge, Anette (Ba3)      Library (upstairs)  
Communal office (Bk2)      Toilet (downstairs)

Bohr's Office

- All talks in Aud A (access through main door @ 9-9.30 am – or ring NBIA doorbell)
  - Tea/Coffee, Lunch in Aud C (opposite)
- Discussions can be had in Aud C, Aud B (next door) or NBIA Lounge (around the corner)
- Desks in Library Reading Rooms (upstairs) - you can skype in Office Bk2 (NBIA basement)
  - Toilets around the corner -> NBIA, or down the stairs



Please wear your badges!

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### Current registrants (42)

Name	Institution	country/region
AHLERS, Markus	NBI	DENMARK
Dr. ARCHIDIACONO, Maria	RWTH Aachen	GERMANY
Dr. BERNAL, Nicolás	Universidad Antonio Nariño	COLOMBIA
Mr. BINDER, Tobias	ITP Göttingen	GERMANY
Prof. BOEHM, Celine	Durham University	FRANCE
Mr. BRINCKMANN, Thejs	RWTH Aachen	GERMANY
Prof. BRINGMANN, Torsten	University of Oslo	NORWAY
Dr. CYR-RACINE, Francis-Yan	Harvard University	UNITED STATES OF AMERICA
Dr. FRANSEN, Mads Toudal	CP3-Origins, Odense	DENMARK
Dr. GARCIA CELY, Camilo Alfredo	ULB	BELGIUM
GOLOVICH, Nathan	UC Davis / LLNL	UNITED STATES OF AMERICA
Dr. GUSTAFSSON, Michael	Göttingen University	GERMANY
Prof. HANSEN, Steen	Dark Cosmology Centre, NBI	DENMARK
Dr. HARVEY, David	EPFL	SWITZERLAND
Dr. IAKUBOVSKIY, Dmytro	NBI	DENMARK
Dr. KAHLHOEFER, Felix	DESY	GERMANY
KERSTEN, Jörn	University of Bergen	NORWAY
Prof. KOUVARIS, Chris	CP3-Origins Odense	DENMARK
Mr. KUMMER, Janis	Universität Hamburg	GERMANY
LOPEZ HONOREZ, Laura	ULB	BELGIUM
Dr. MASSEY, Richard	Durham University	UNITED KINGDOM
Dr. MERTEN, Julian	INAF-Bologna / University of Oxford	ITALY
Dr. MORE, Surhud	Kavli IPMU	JAPAN
Dr. PONTZEN, Andrew	University College London	UNITED KINGDOM
Dr. RAMEEZ, Mohamed	NBI	DENMARK
Mr. ROBERTSON, Andrew	Institute for Computational Cosmology - Durham	UNITED KINGDOM
Prof. SAHA, Prasenjit	University of Zurich	SWITZERLAND
Prof. SARKAR, Subir	NBI and Oxford University	UNITED KINGDOM
SCHMIDT-HOBERG, Kai	DESY	GERMANY
Ms. SOKOLENKO, Anastasia	University of Oslo	NORWAY
Dr. TITTLE, Eric	University of Edinburgh	UNITED KINGDOM
Dr. TULIN, Sean	York University	CANADA
Mr. TYTGAT, Michel	Université Libre de Bruxelles	BELGIUM
VALLI, Mauro	INFN Rome	ITALY
Dr. VISINELLI, Luca	NORDITA and Stockholm University	SWEDEN
Prof. VOGELSBERGER, Mark	MIT	UNITED STATES OF AMERICA
Dr. WILD, Sebastian	DESY	GERMANY
Prof. WILLIAMS, Liliya	University of Minnesota	UNITED STATES OF AMERICA
WITTMAN, David	UC Davis	UNITED STATES OF AMERICA
Prof. YU, Hai-Bo	University of California, Riverside	UNITED STATES OF AMERICA
Mr. ZALDIVAR, Bryan	LAPTh, Annecy	FRANCE
Dr. ZAVALA, Jesus	University of Iceland	ICELAND

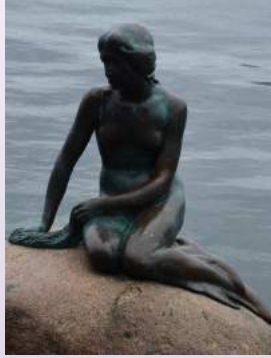
For any assistance please contact the NBIA Administrator



**Anette Studsgard**  
Office: Ba3  
+45 30450072

- ❖ Traditional group photo (**right now**)
- ❖ Tour of NBI/Bohr's Office  
**Today 13:15** (meet in Aud A)
- ❖ Welcome party  
**Today 17:30** (outside if pleasant)
- ❖ Excursion to *Lousiana* (with lunch)  
**Wednesday** (Hotel pickup at 10:15)
- ❖ Workshop dinner at *SALT*  
**Friday 19:00** (10 min walk ↶ Hotel)

... and do not forget to enjoy Copenhagen!



See suggestions under 'Out & About' (webpage) and leaflets in Aud C