

# Search for (un)predicted streaming DM exotica

*Why no DM signal yet?*

K. Zioutas

University of Patras / Greece

**Abstract:** *Streaming DM may be the better source for its discovery than the isotropic DM. Because, a large flux enhancement can take place, temporally, due to gravitational lensing when the Sun and/or a planet are aligned with the stream. Of interest are axion miniclusters, in particular, if the solar system has trapped one during its formation. Wide-band axion antennae fit this concept, but also the proposed fast narrow band scanning. A network of detectors can provide full time coverage (and large axion mass acceptance). Other DM searches may profit from this proposal.*

## Further reading:

Z., Anastassopoulos, Bertolucci, Cantatore, Cetin, Fischer, Funk, Gardikiotis, Hoffmann, Hofmann, Karuza, Maroudas, Semertzidis, Tkachev [arXiv:1703.01436](https://arxiv.org/abs/1703.01436) ;  
Fischer, Semertzidis, Z., <https://ep-news.web.cern.ch/content/search-axions-streaming-dark-matter>.

Fermi-LAT Spring Collaboration Meeting

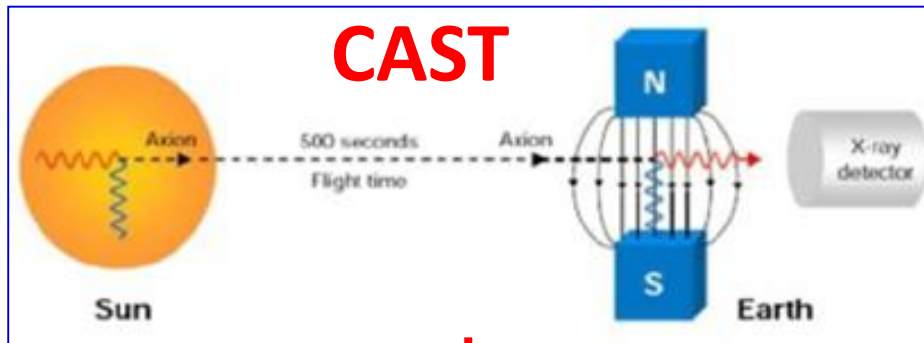
CERN, 27-30 March 2017

**CAST** ↔ **Fermi-LAT**

7000 [T·m]<sup>2</sup>

~10<sup>16</sup> x CAST

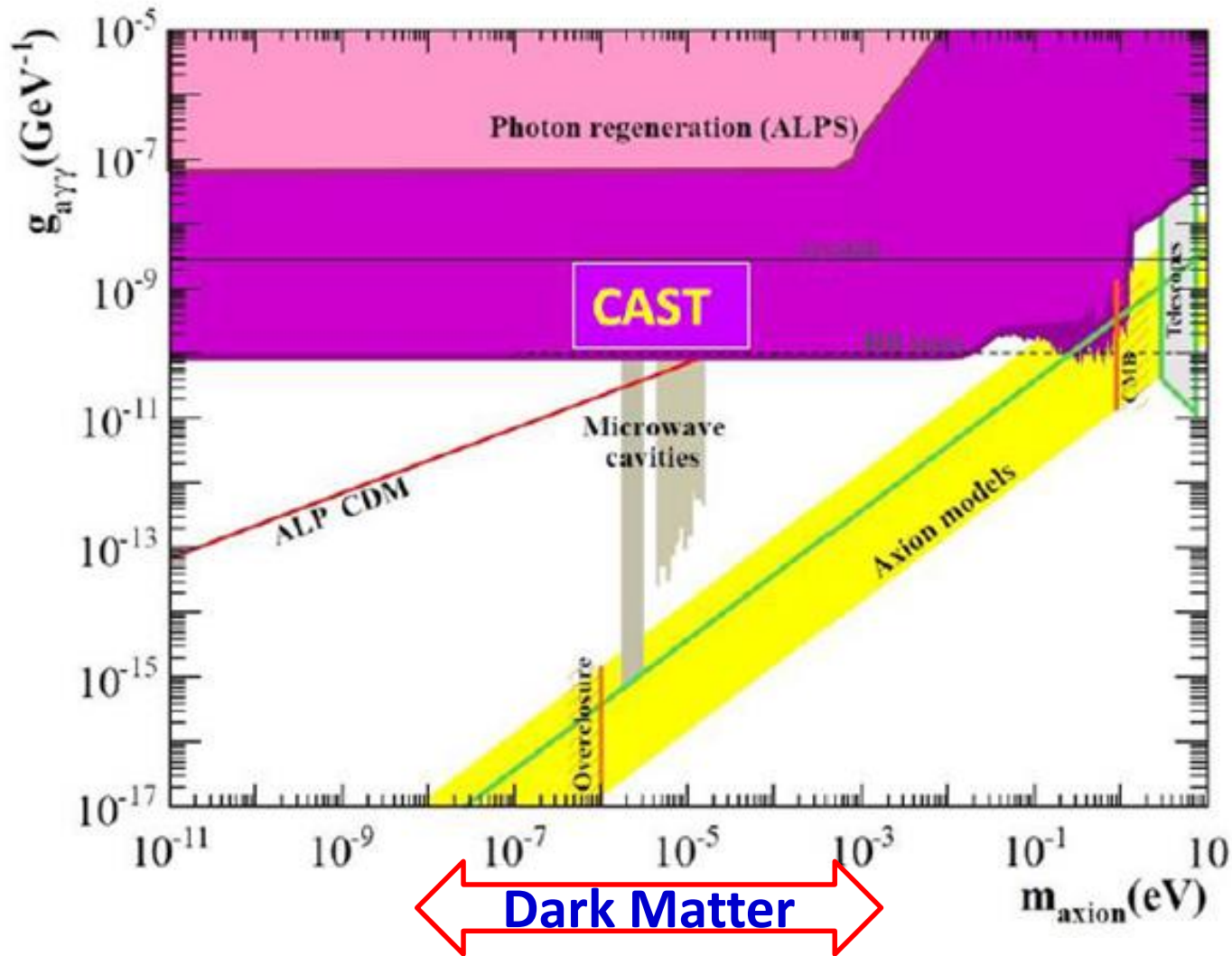
Solar Chameleons in CAST.  
→ In Fermi-LAT?

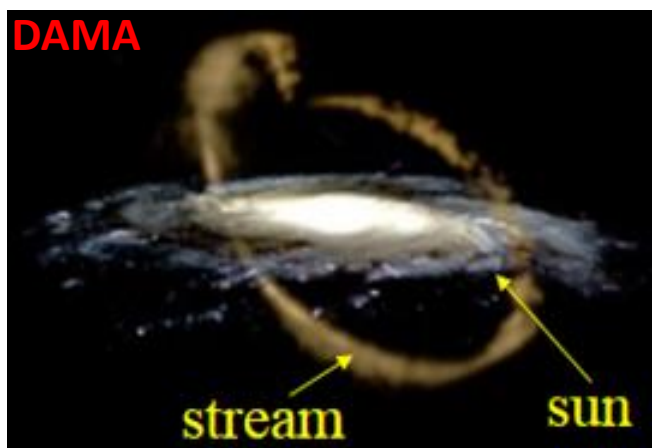
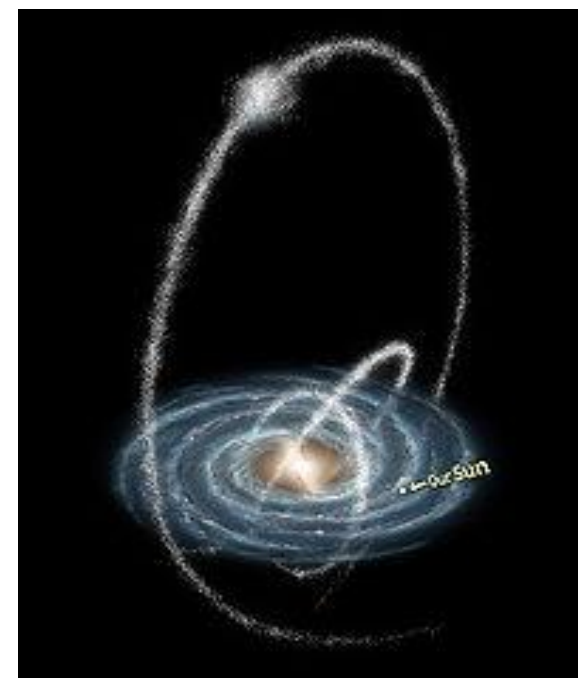
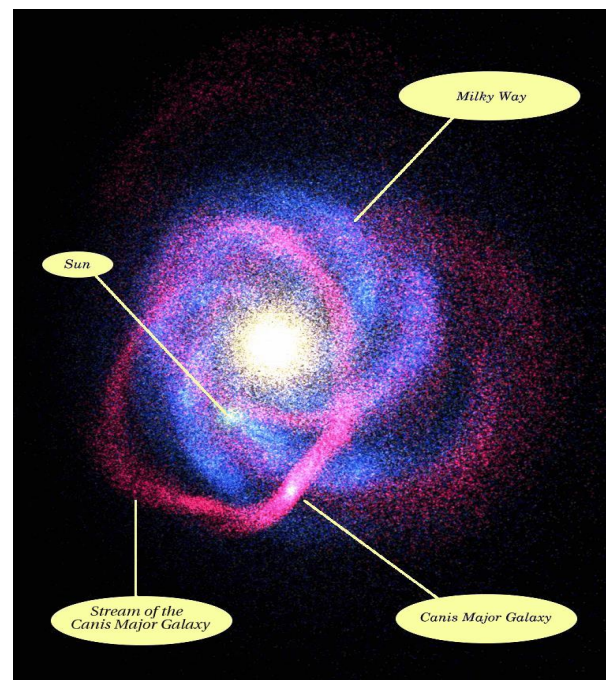
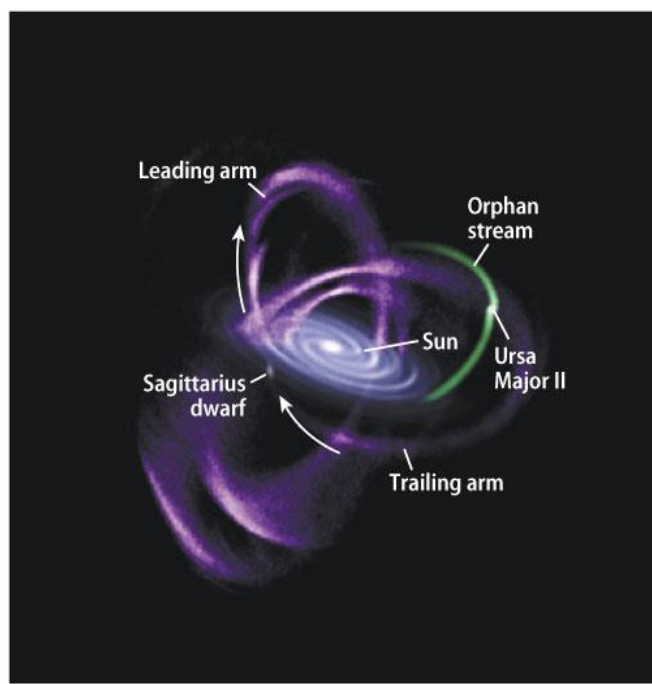


2003-2015:  
Solar axions

**2017** → **NATURE paper!**

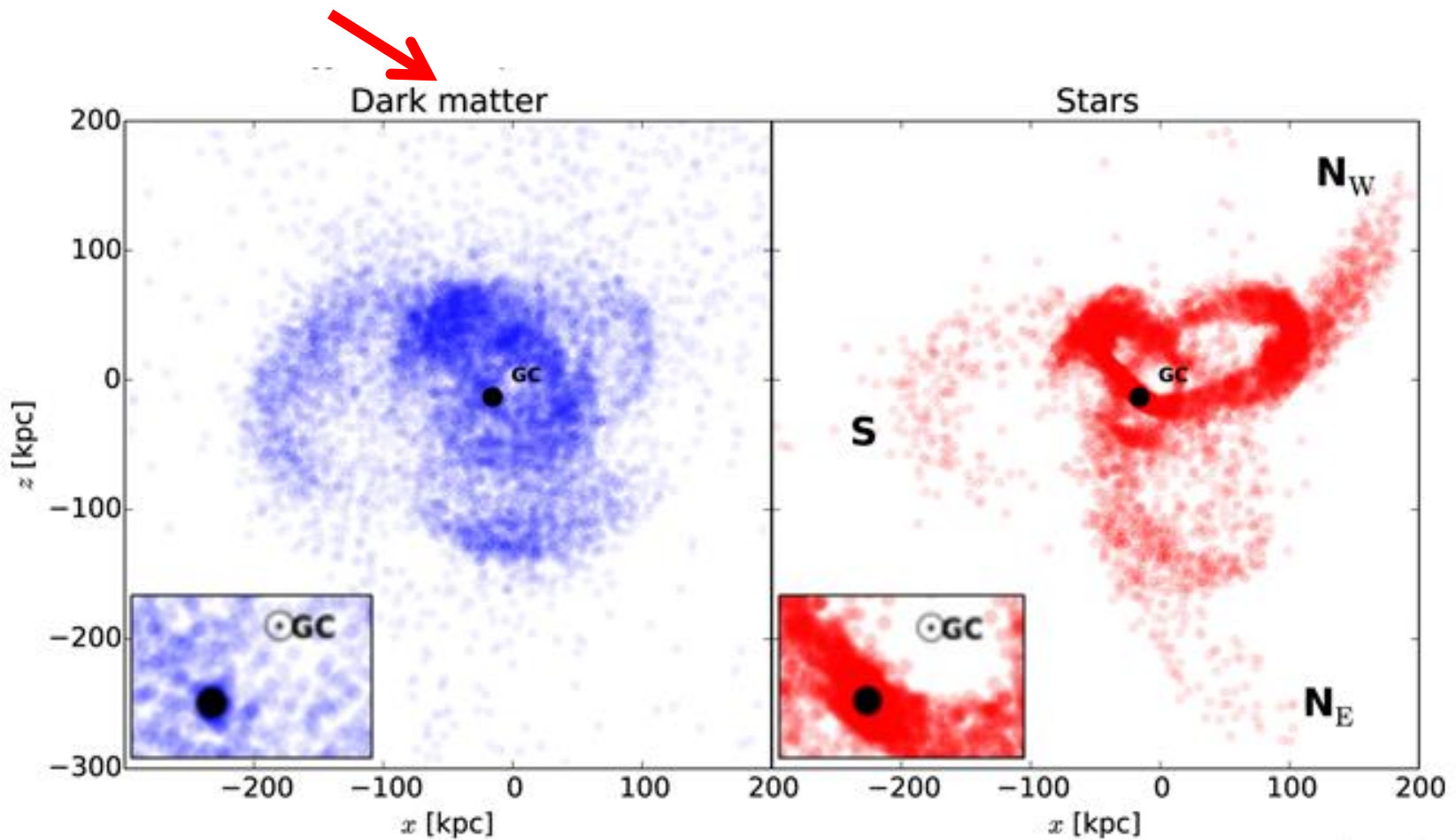
Detect / exclude **CaB** → **DM streams**





**Tidal streams of Sagittarius Dwarf satellite galaxy (SagDEG) of Milky Way, etc. ... we know neither the SGR's original mass nor where the dwarf came from.**  
 DOI: [10.1093/mnras/stw2328](https://doi.org/10.1093/mnras/stw2328) <https://arxiv.org/abs/1607.00803>

**Caustics (P. Sikivie), DDDM (L. Randall), ...**

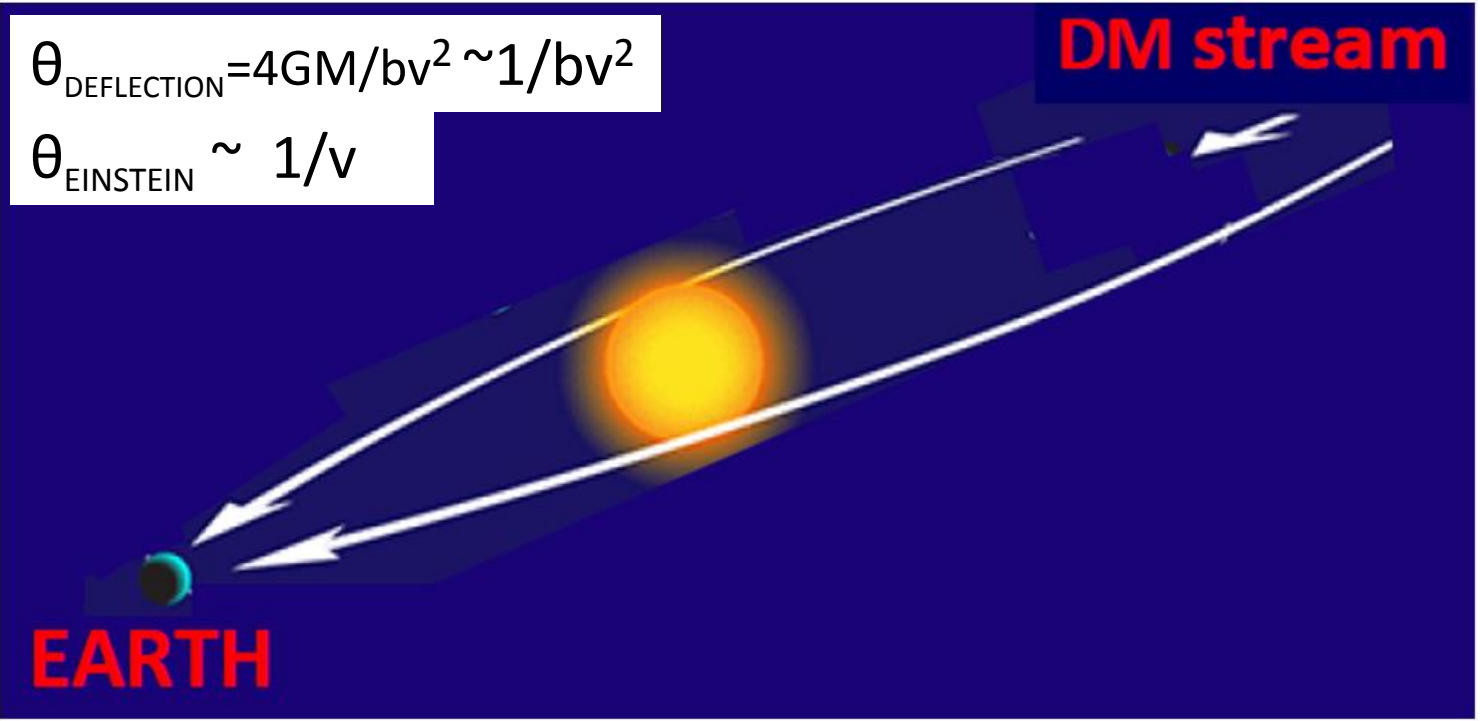


*The Sagittarius Stream is a complex structure made of tidally stripped stars and DM from the Sagittarius Dwarf Galaxy due to the ongoing merging with our Galaxy the last  $\sim 5$  Gyears. The locations of the Sun (●) and the galactic center (GC) are given. The inserts show expanded the inner galactic region.*

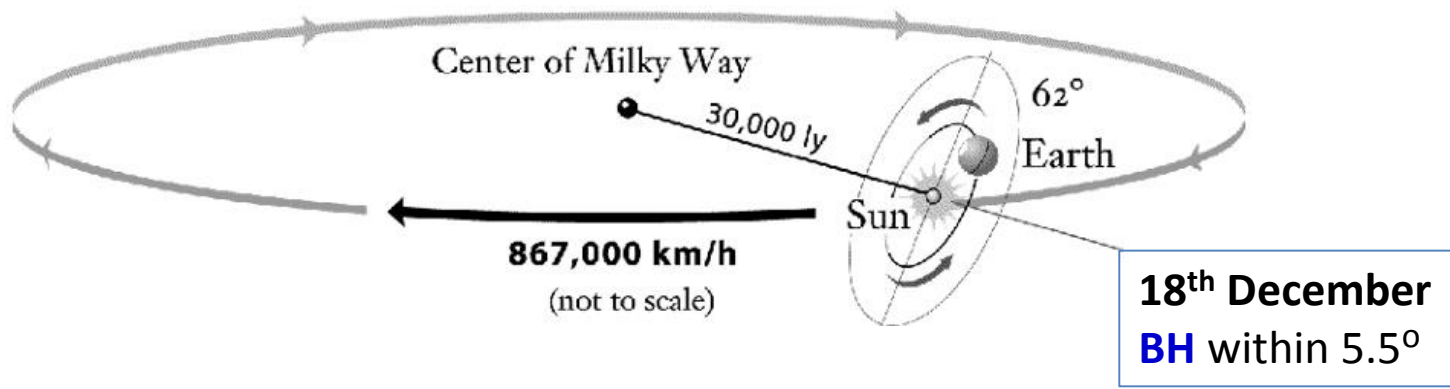
**Abraham Loeb / Harvard**

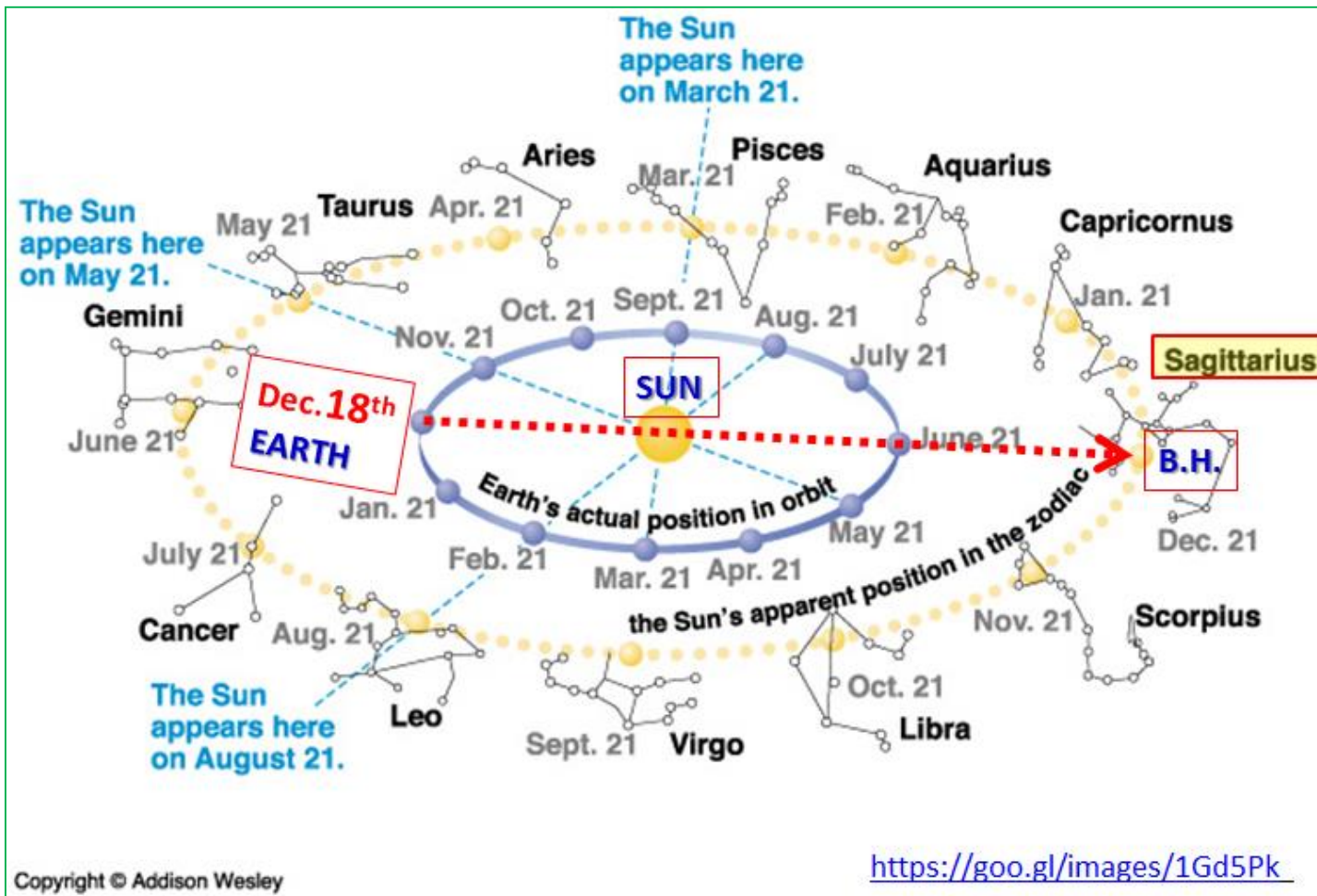
**→ DM streams aligned with Sun-Earth? → simulation ⇒ GAIA mission!**

**SUN = gravitational lens** for  $v < 0.1c$  at 1AU  $\Rightarrow$  Magnification of a remote source



$10^{\sim 8} \times$





## First related work:

### Gravitational lensing by the Sun of non-relativistic penetrating particles

D. Hoffmann, J. Jacoby, K. Z., *Astropart. Phys.* 20 (2003) 73; [http://dx.doi.org/10.1016/S0927-6505\(03\)00138-5](http://dx.doi.org/10.1016/S0927-6505(03)00138-5)

### Flux Enhancement of Slow-moving Particles by Sun or Jupiter: Can they be detected?

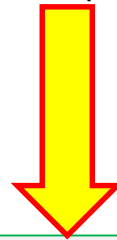
B.R. Patla, R.J. Nemiroff, D. H.H. Hoffmann, K. Z., *ApJ.* 780 (2014) 158; <https://arxiv.org/abs/1305.2454>

# More DM axions @ solar system?

**Tidal streams from axion miniclusters + direct axion searches**

**Stream-crossing:** 2-3 days / 20yr with axion signal amplification  $\sim 10x$

Tinyakov, Tkachev, Z., JCAP 1601 (2016) no.01, 035 <https://arxiv.org/abs/1512.02884>



**Axion minicluster trapped during solar system formation**

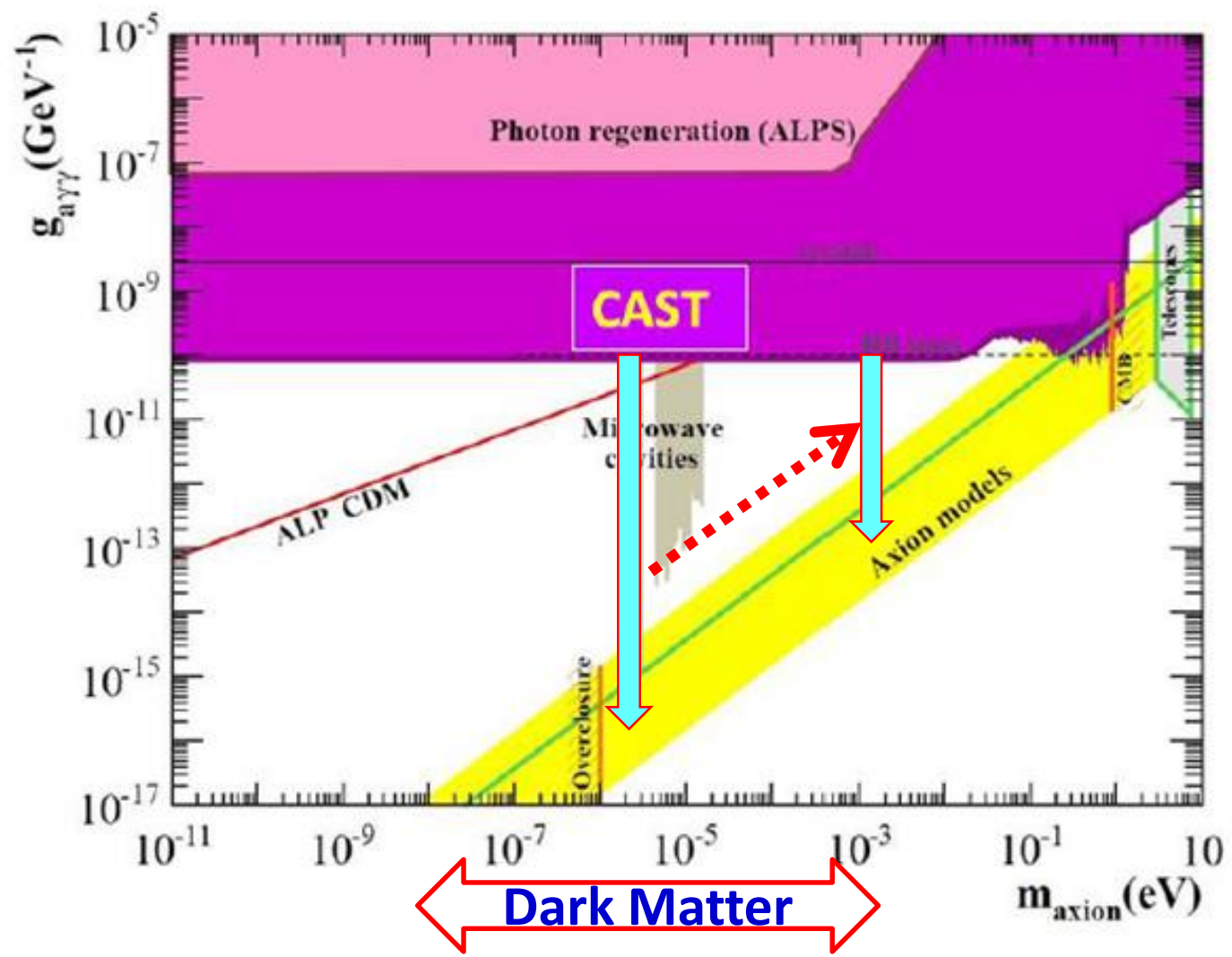
$\Rightarrow$  *max. density enhancement*  $\sim 10^5$

$\Rightarrow$  *"Duty Cycle"* .....  $\sim 1\%$

Igor Tkachev / INR - Moscow

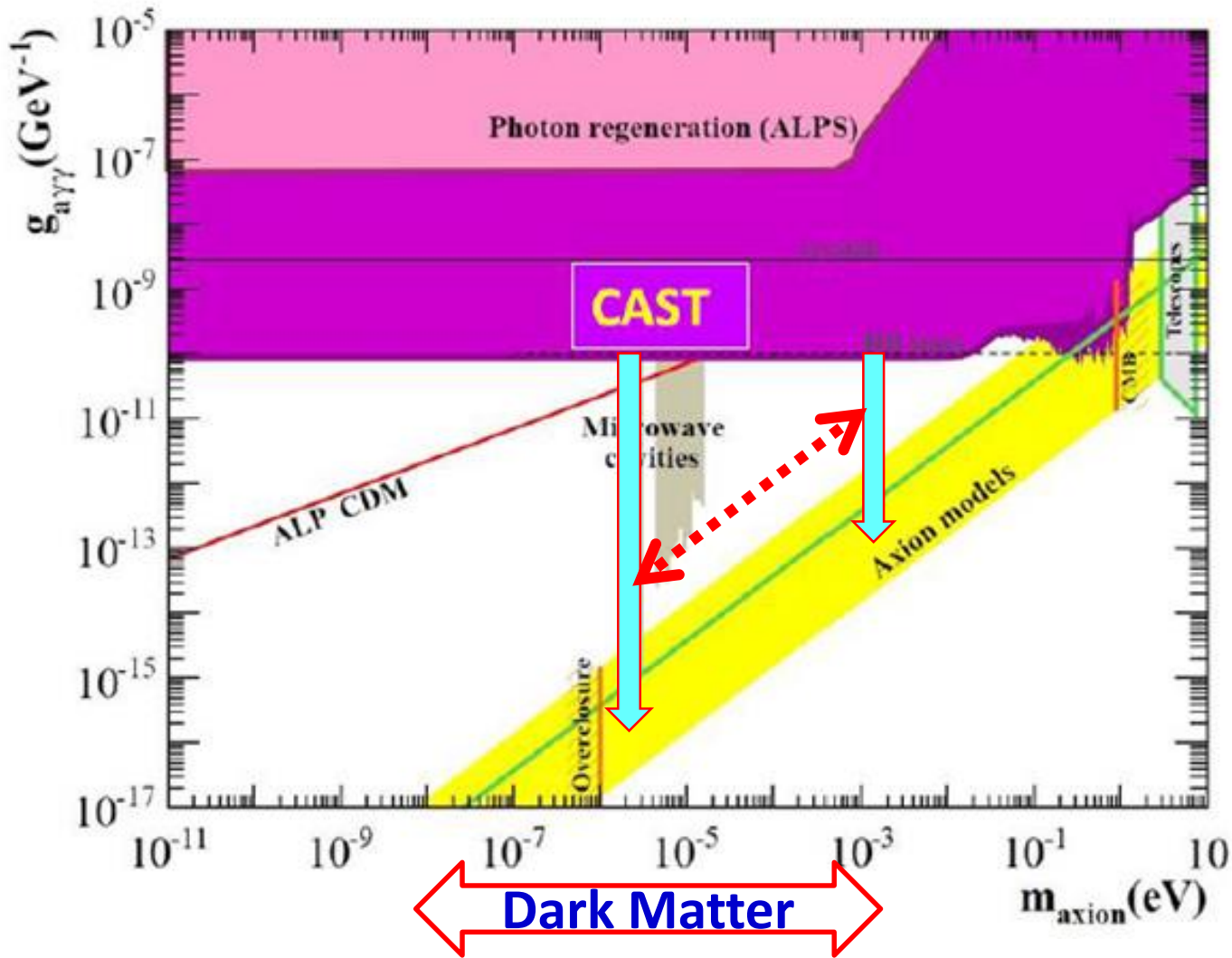


present



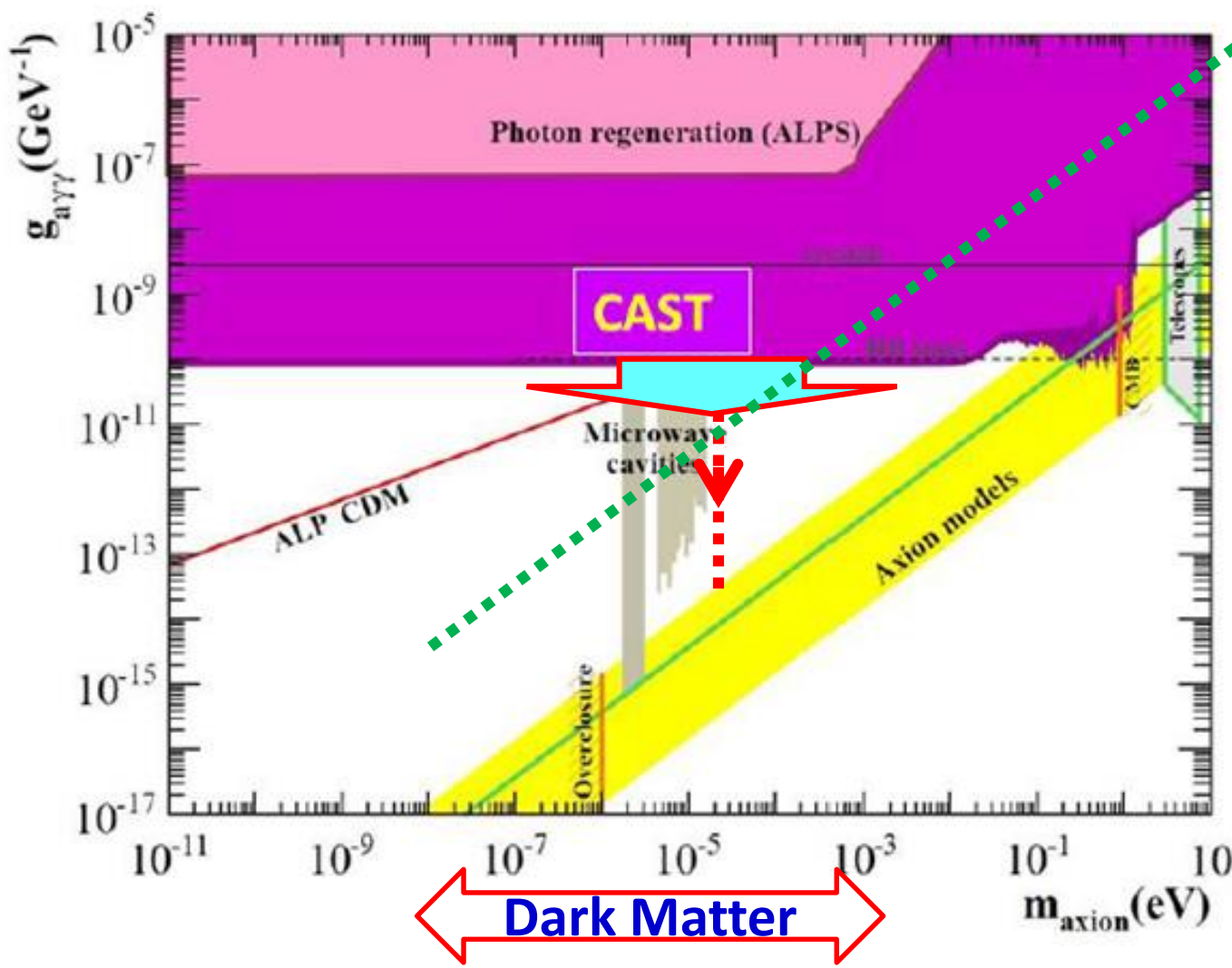
**SLOW** narrow band scanning ...DM axions

present suggestion

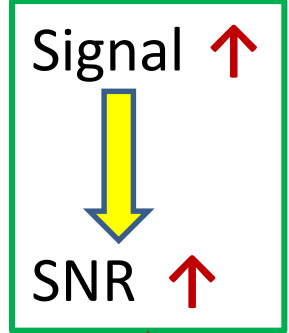


FAST narrow band scanning ...DM axions

present suggestion

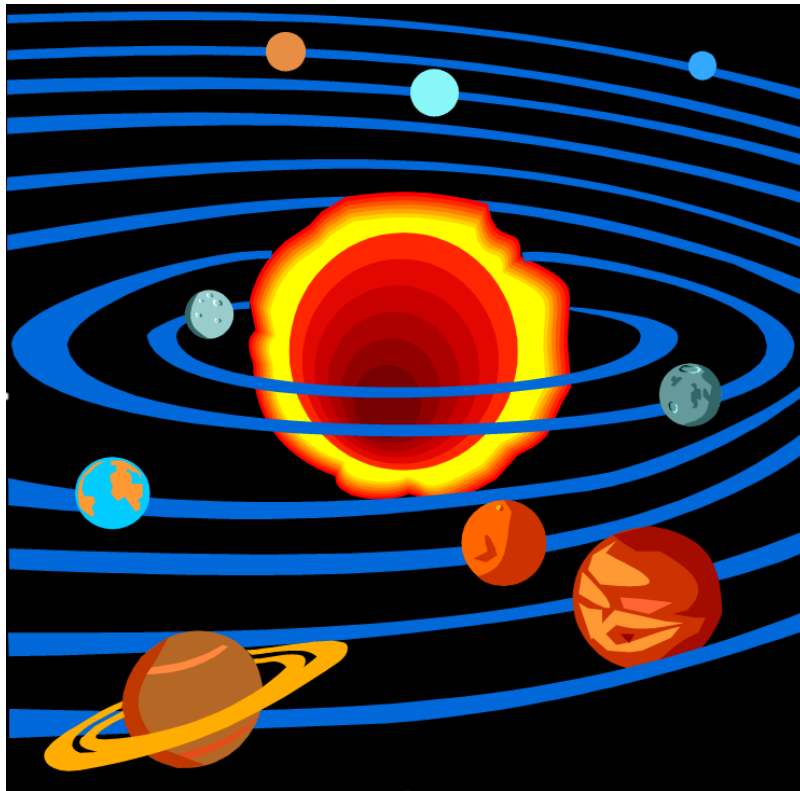


temporally



$a$ MCs  
 $\sim 10^5 \times$

Wide band ...DM axions enhanced



### Unknown streams

trapped  $\alpha$ -minicluster  $\approx 10^{-12}M_{\odot}$  ( $\sim 10^5 \rho_{\text{dm}}$ )  $\Rightarrow$  NO GL

+

(Un)predictable planetary/solar align's  $\rightarrow$

$v_{\text{stream}} = ?$

**Continuous *fast narrow band* scanning**

Naturally:

**axion signal  $\Leftrightarrow$  planetary correlations**

**Unexpected...** solar / terrestrial activity =  $f(\Theta_{\text{planets}})$

[arXiv:1602.03666](https://arxiv.org/abs/1602.03666) **The Sun + its Planets as detectors for *invisible matter***  
S. Bertolucci, K.Z., S. Hofmann, M. Maroudas

## Summary

### Transient increase of DM axion flux by:

- **Gravitational lensing** towards the Earth of slow speed streams
  - by the Sun → Earth – Sun – Source alignment
  - by the Planet-X → Earth – Planet-X – Source alignment
- **Trapped axion minicluster(s)** by the solar system
  - $\sim 10^{-2}$  /year + planetary lensing
- **Wide-band / *fast narrow band scanning***
- SNR ↑
- A coordinated network of DM experiments
- ❑ **DM searches: underground & orbit ()**
  - *planetary correlations?*
  - *re-analysis?*

Fermi-LAT?

# 13th Patras Workshop on Axions, WIMPs and WISPs

15-19 May 2017

Thessaloniki, Greece

Fermi-LAT  
Maurizio Gianotti

## Scientific Programme

- Direct and indirect searches for Dark Matter
- Direct and indirect searches for Axions & WISPs
- Searches for Hidden Sector Photons
- Astrophysical signatures for dark matter
- Review of collider experiments
- New developments: theory & experiment
- Scalar Dark Energy: theory & experiment

## Organizing committee:

Konstantin Zioutas (Chair, University of Patras)  
Vassilis Anastassopoulos (University of Patras)  
Laura Baudis (University of Zurich)  
Joerg Jaeckel (University of Heidelberg)  
Axel Lindner (DESY)  
Andreas Ringwald (DESY)  
Marc Schumann (University of Freiburg)  
Yannis Semertzidis (CAPP/IBS & KAIST)

Deadline for abstract submission, early registration  
and room reservation: 31 March 2017



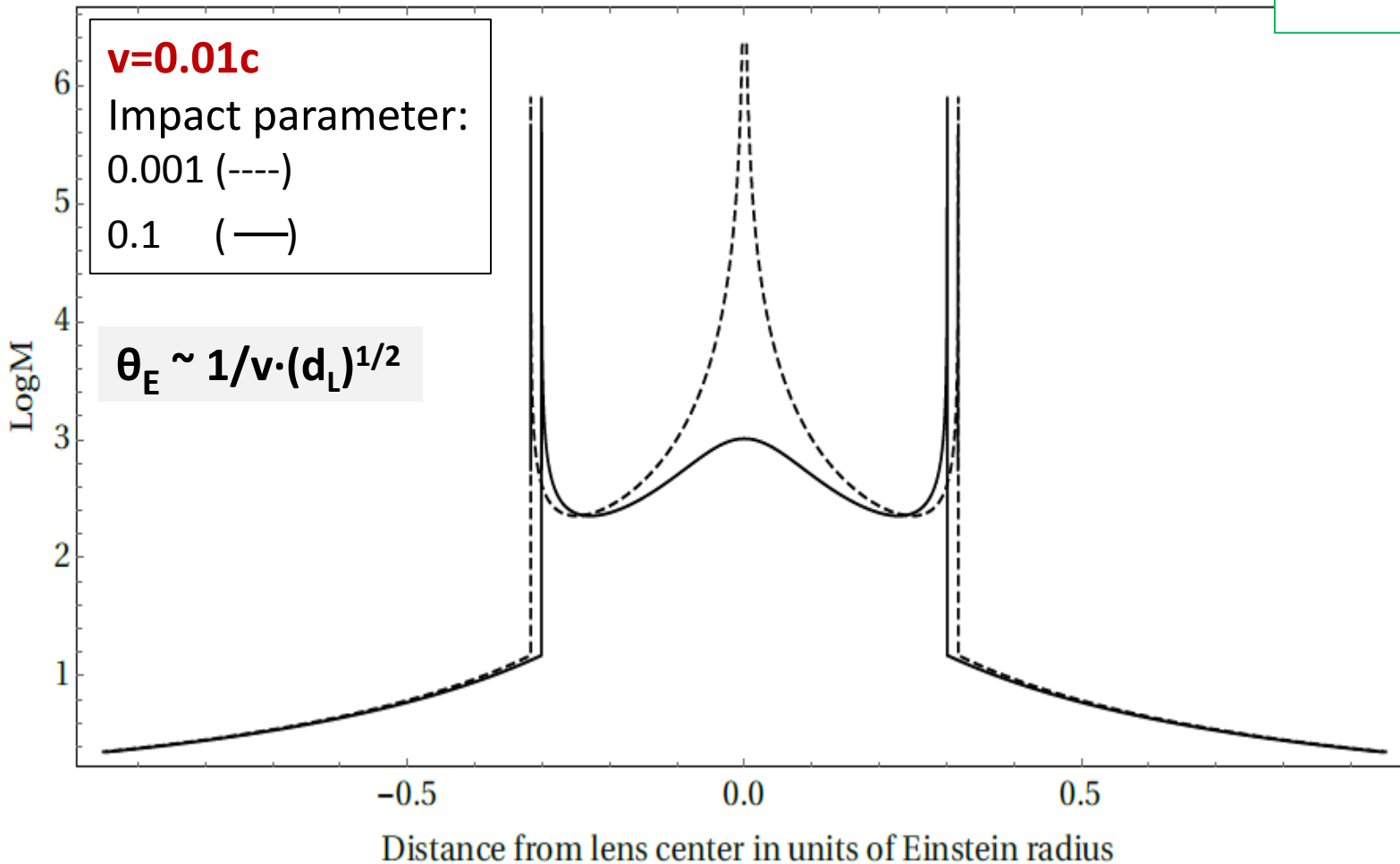
<http://axion-wimp.desy.de>

SPONSORS: CERN, DESY, UNIVERSITY OF FREIBURG, UNIVERSITY OF HEIDELBERG, UNIVERSITY OF PATRAS, UNIVERSITÄT OF ZÜRICH, CAST

Additional slides

# Magnification of the source by the Sun

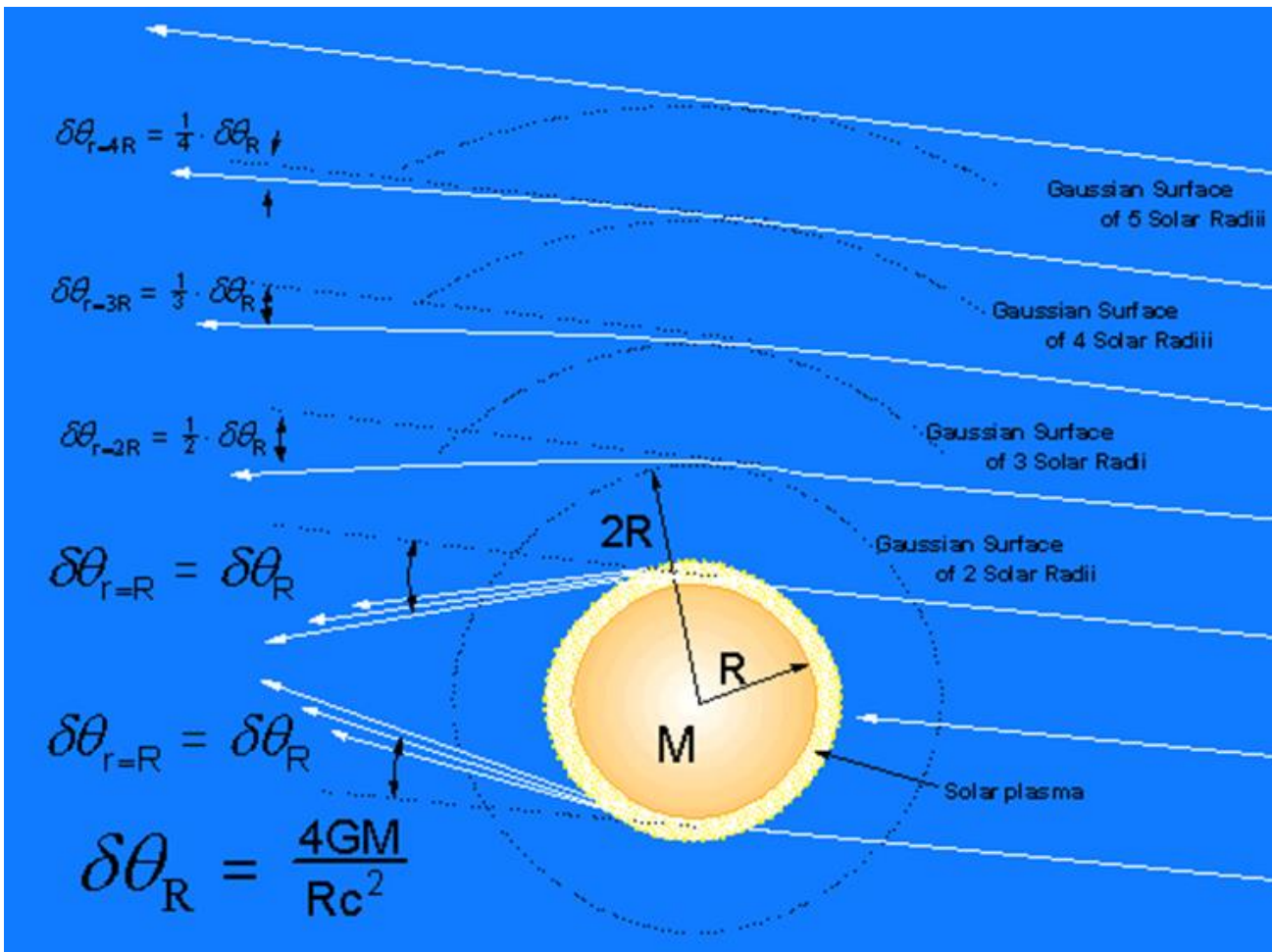
=>  $10^8 \rightarrow 10$



$10^{-4} \times \rho_{DM}$

B.R. Patla / NIST





$$\theta_E = \sqrt{\frac{4GM}{c^2} \frac{d_{LS}}{d_L d_S}}$$

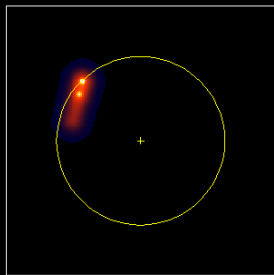
- Angle of deflection:  $\Theta = 4GM/bc^2$

# Lensing Galaxy

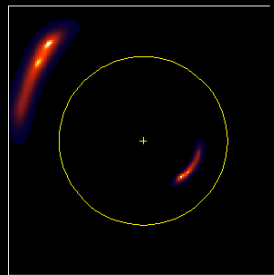


[http://spiff.rit.edu/classes/phys240/lectures/grav\\_lens/grav\\_lens.html](http://spiff.rit.edu/classes/phys240/lectures/grav_lens/grav_lens.html)

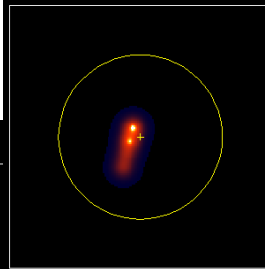
Background Radio Source



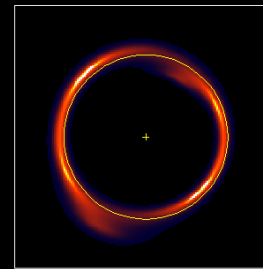
Lensed Image of the Radio Source



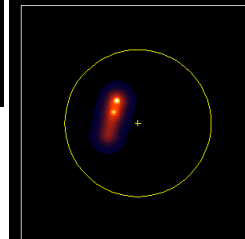
Background Radio Source



Lensed Image of the Radio Source



Background Radio Source



Lensed Image of the Radio Source

