New manifestations of the dark Universe

⇒ CGs

⇒ 11yr

K. Zioutas
University of Patras / Greece

Work with:

- V. Anastassopoulos, T. Papaevangelou, Y. Semertzidis, M. Tsagri, ...
- K. Dennerl, D.H.H. Hoffmann , T. Papaevangelou .

Based on:

L. Di Lella, K. Zioutas, Astroparticle Phys. 19 (**2003**) 145

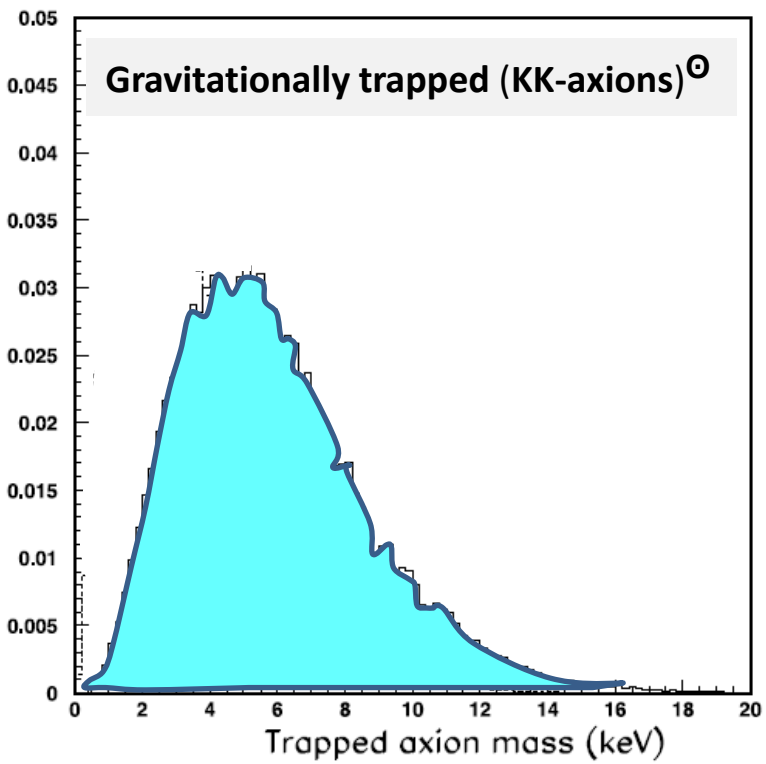
D.H.H. Hoffmann, J. Jacoby, K. Zioutas, Astroparticle Phys. 20 **(2003)** 73
UPDATED 2013: B.R. Patla, R.J. Nemiroff, D.H.H. Hoffmann, K. Zioutas, arXiv:1305.

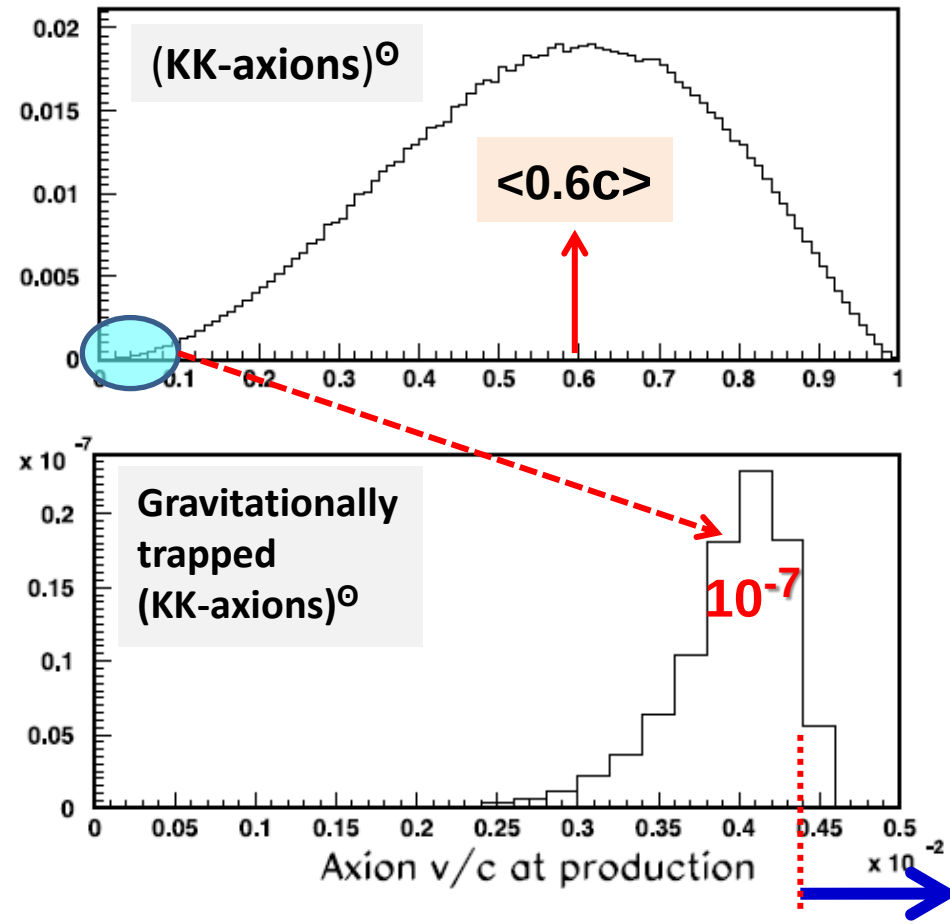
K. Zioutas, D.H.H. Hoffmann, K. Dennerl, T. Papaevangelou, Science 306 (**2004**) 1485
UPDATE 2013

Acknowledging Biju Patla / SAO-Harvard for clarifications

Massive solar KK-axions

=> Generic example.



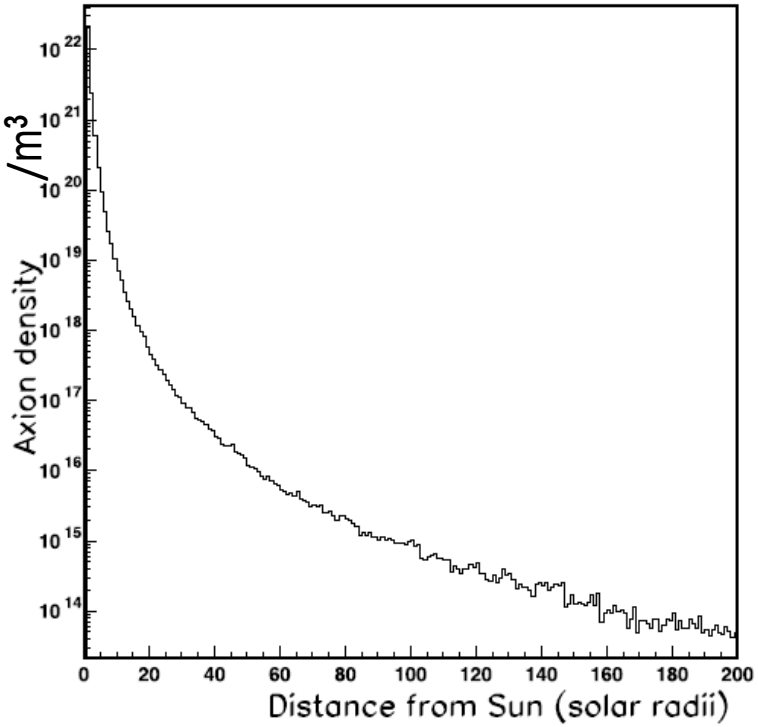


Slow particles from stars!

$v_{esc} \geq 0$

L. Di Lella, A. Pilaftsis, G. Raffelt, K. Z., Phys. Rev. **D62** (**2000**) 125011;
L. Di Lella, K. Z., Astroparticle Phys. 19 (**2003**) 145

Massive solar KK-axions



KK-axion density of gravitationally self-trapped axions around the Sun.

Diffuse solar X-ray halo

⇩

"ghost plasma"

⇩

PULSARs, CGs…**?**

$$\tau_{decay} \sim \frac{1}{g_{a\gamma\gamma}^2 \cdot m_a^3}$$

[1min] = [1.5x10^{-3} GeV^{-1}]x[1keV]

V_{esc} ≈ 615 km/s ⇨ **Pulsar: v_{esc} >0.3 c**

10^{-7} **=>** **~1 (?)**

L. Di Lella, K. Zioutas / Astroparticle Phys. 19 (**2003**) 145

Pulsar (PSR J1648−4611)

- **Diffuse X-ray emission** ≈ $7 \cdot 10^{32}$ erg/s (2-10keV)
- **Compact size,** ≈10x the expected
- » the expected spin-down luminosity (10^{31} erg/s)

http://arxiv.org/pdf/1301.5940v1.pdf

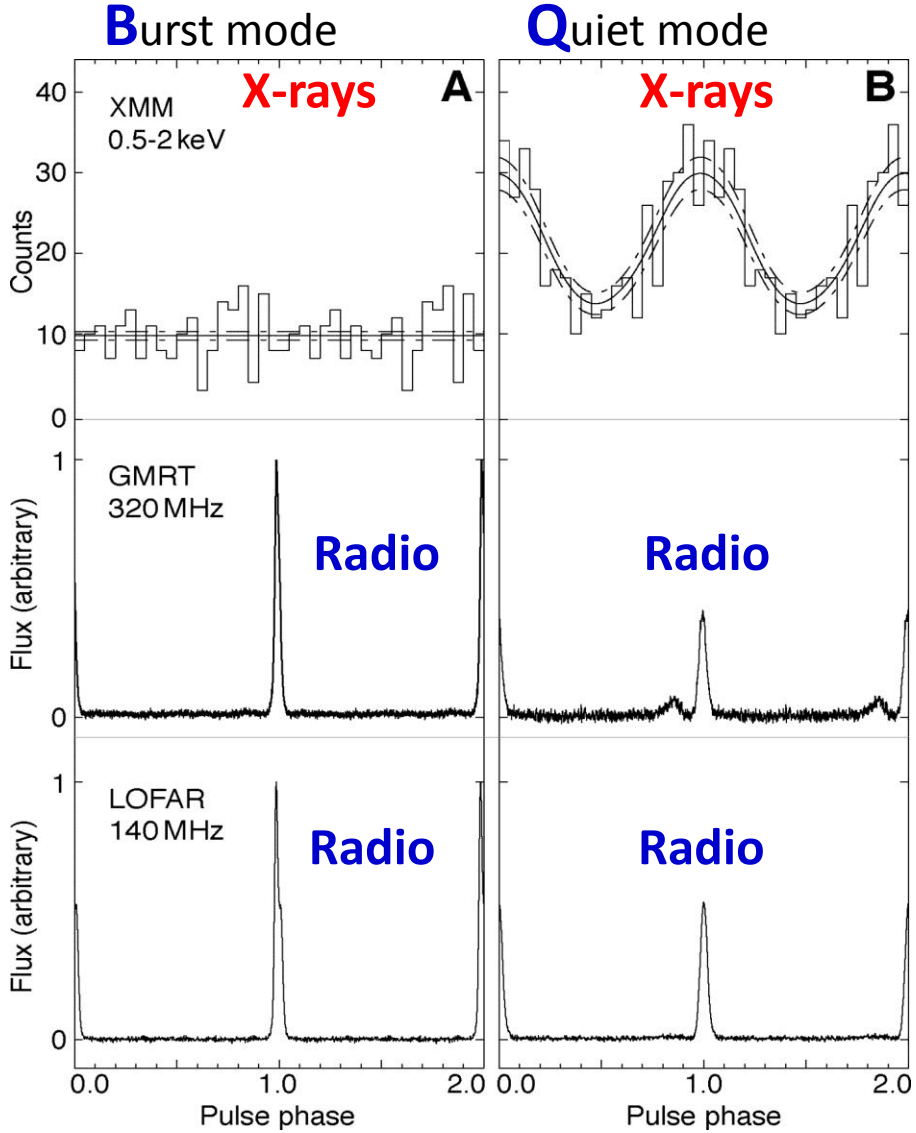
Decaying trapped exotica?

after 45 years:

"The exact mechanism by which pulsars shine is still unknown"!

http://sciencenews.com/articles/2013/01/24/chameleon.pulsar.baffles.astronomers

X-ray / radio pulse profiles of … → **"*Chameleon pulsar*"**



W. Hermsen *et al*., Science 339 (**2013**) 436

2013

*" ..why a **pulsar** should undergo such dramatic and unpredictable changes is completely unknown."*

http://esciencenews.com/articles/2013/01/24/chameleon.pulsar.baffles.astronomers

Galaxy clusters are highly important test sites for cosmology ….

M. Meneghetti et al., A&A 514 (**2010**) A93
http://www.aanda.org/articles/aa/pdf/2010/06/aa13222-09.pdf

Cluster masses … ~$10^{14}M_{\odot}$ to >$10^{15}M_{\odot}$, the vast majority of which appears to be **DM that emits no detectable radiation.**

G. Mark Voit; Rev.Mod.Phys.77(**2005**)207;
http://arxiv.org/pdf/astro-ph/0410173.pdf

But, coincides with places of strong X-rays emission !!

What if?

Galaxy Clusters:

Discrepancy predicted due to massive exotica like KK-axions:

"*Ghost plasma*" is complicating interpretation >> `unpredictably`!

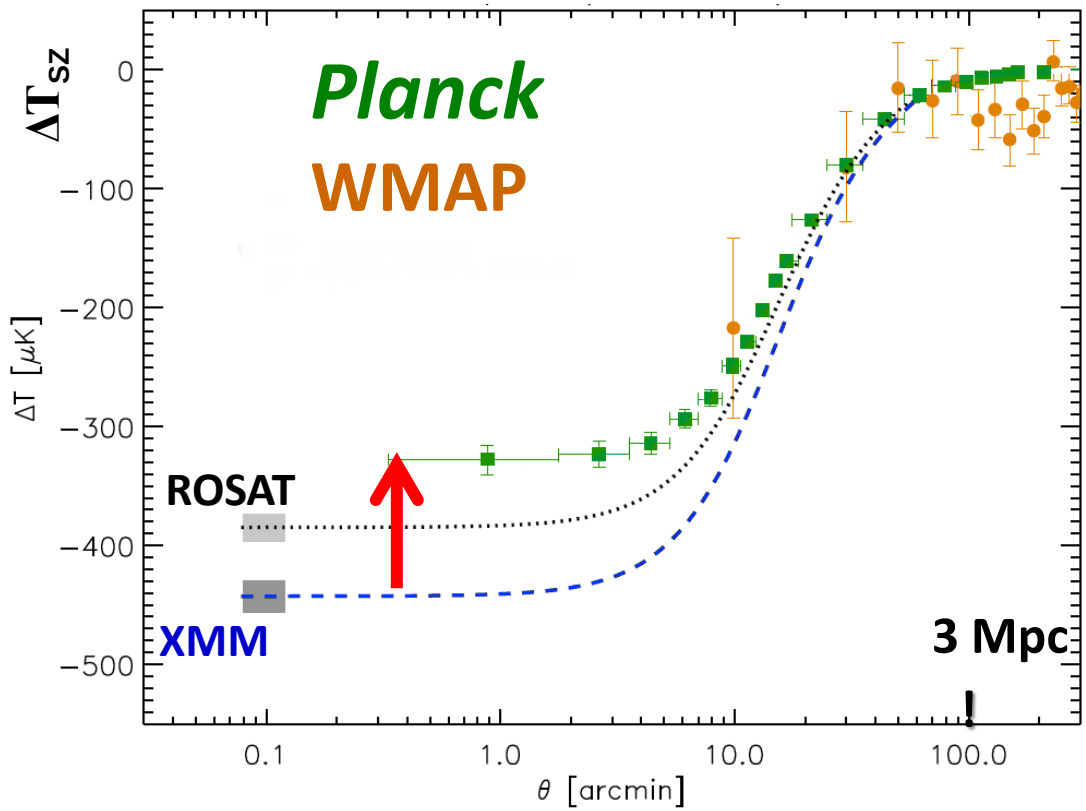
K. Zioutas, D.H.H. Hoffmann, K. Dennerl, T. Papaevangelou, Science 306 (**2004**) 1485

To be quantified

Work in preparation [**2013**]

>>> decaying DM in CGs

Coma cluster: SZ *vs.* X-rays => deficit



"… **discrepancy**….." "…**mismatch**…"

"… **tension** between SZ and X-rays.."

ROSAT ≠ **XMM**

different ΔE ≠ discrepancy

$$L_{x\text{-rays}} \sim \frac{\rho^2}{T^{1/2}}$$ /cm³

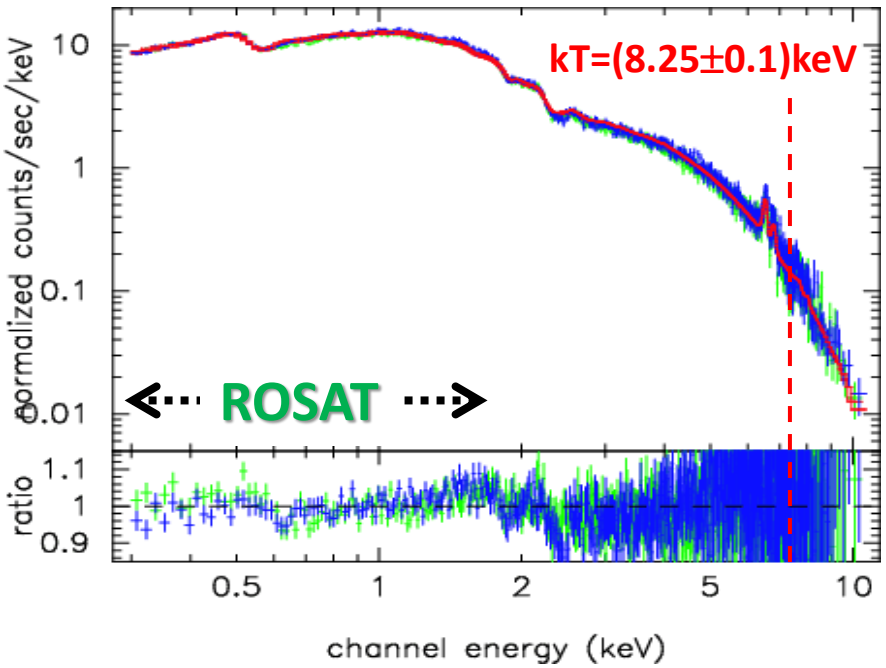
+

$$\Delta T_{SZ} \sim \rho \cdot T$$ /cm²

kT = (8.25±0.1) keV

R. Fusco-Femiano *et al.* ApJ. 763 **(2013)** L3; http://xxx.lanl.gov/pdf/1212.3082.pdf and ref's therein.

Coma cluster



"Still, X-ray observations =
one of the fundamental methods to recover the galaxy cluster mass"
(arXiv:1305.5519v1).

M. Arnaud *et al.*, A&A 365 (**2001**) L67
http://dx.doi.org/10.1051/0004-6361:20000195

The Coma spectrum can be well approximated by a thermal plasma emission model with T=8.2 keV.

A. A. Lutovinov *et al.*, ApJ 687 **(2008)** 968;
http://iopscience.iop.org/0004-637X/687/2/968/

$L_x \approx 2.6 \cdot 10^{44}$ erg/s
$M_{coma} \approx 7 \cdot 10^{14} M_\odot$
$1 M_\odot \approx 1.2 \cdot 10^{57}$ neutrons
$\approx 10^{54}$ erg
Assuming DM ~ 7x baryonic Matter:
$M_{DM} \approx 6 \cdot 10^{14} M_\odot$
$L_{DM\text{-}x} \approx 2.6 \cdot 10^{43}$ erg/s

$\tau_{DM} \approx 2.4 \cdot 10^{25}$ sec ≈ $5 \cdot 10^7$ x 13.7Gyears => $\tau_{universe}$!?

$T_{ICM} \approx 8.2$keV
z ≈ 0.0231 (6925km/s)
Distance 102Mpc
> 1000 galaxies
http://en.wikipedia.org/wiki/Coma_Cluster

Assuming solar KK-axions with m_{KK}=8keV: **$g_{a\gamma\gamma} \sim 7.5 \cdot 10^{-17}$ GeV^{-1}**

$$\tau_{decay} \sim \frac{1}{g_{a\gamma\gamma}^2 \cdot m_a^3}$$

[1min] = [1.5×10^{-3} GeV^{-1}]x[1keV]

D.H.H. Hoffmann, J. Jacoby, Astropart. Phys. 20 **(2003)** 73 ⇢ $\Theta_{\mathbf{deflection}} \sim \frac{M(R)}{R\,v^2}$

Gravitational lensing: Sun, Jupiter, ..

~10^{6}x flux enhancement

Transparent Sun	=>	Earth	>>	**v ≈ 0.010c – 0.2c**
Jupiter	=>	Earth	>>	**v ~ 0.001c – 0.005c**

B.R. Patla, R.J. Nemiroff, D.H. H. Hoffmann, K. Zioutas, arXiv:1305.2454

Further >>

Earth => Sun >> V ~ 10^{-3}c - 10^{-2}c

....

Moon => Earth >> V ≤ 10^{-4}c (<22 km/s)

- ~10^4 signal enhancement + modulation (27.3 d) => **ID**
- >5h delayed OFF-pointing behind the Moon (…Sun).

[Slow particles from point sources / dark matter stream]

>>> Fourier analysis

e.g.: =>

1859

The 11 years solar cycle

=> $P^{Jupiter} = 11.8yr$

Q: The clock is internal? External? OR both??!

Planetary Tides (~$10^{-12}F_{\odot}$) on the Sun related to Sunspots + solar activity(!?)

HOW?

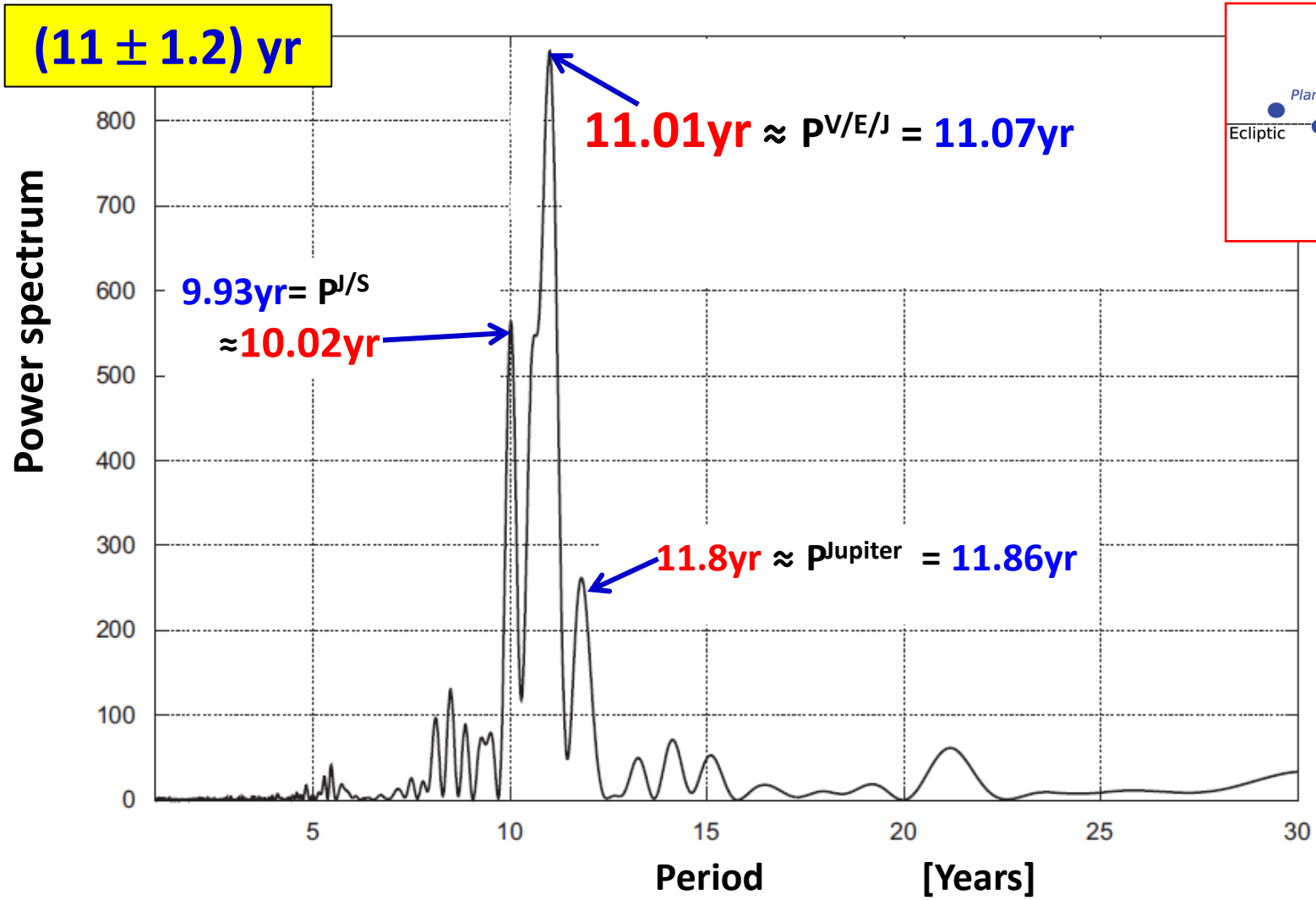
Feedback in planetary periods, not observed!

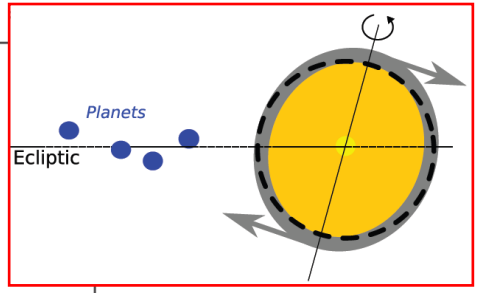
ApJ. 487(**1997**)930

2013

...we hesitate to tell ... **they are NOT related**

http://link.springer.com/article/10.1007%2Fs11207-013-0288-6#page-1 Sol.Phys.286(**2013**) 303





2012

J.A. Abreu *et al.*, A&A 548 (2012) A88; http://www.aanda.org/articles/aa/pdf/2012/12/aa19997-12.pdf

Power spectrum analysis of the monthly average sunspot number record reveals the existence of three peaks (**red**). Periods of planetary tidal forces (**blue**).

N. Scafetta, J. Atm. & Sol.-Terr. Phys. 80 (**2012**) 296; http://www.sciencedirect.com/science/article/pii/S1364682612000648

The new scenario for 11yr:

Instead of planetary tides:

Planetary gravitational DM flux enhancement $\leq 10^6$ @ Sun

At alignment : much more enhancement**!!?**

[B. Patla, **2013**]

The missing mechanism**!?**

What next?

- Quantify planetary gravitational lensing scenario

- If external impact on the Sun:

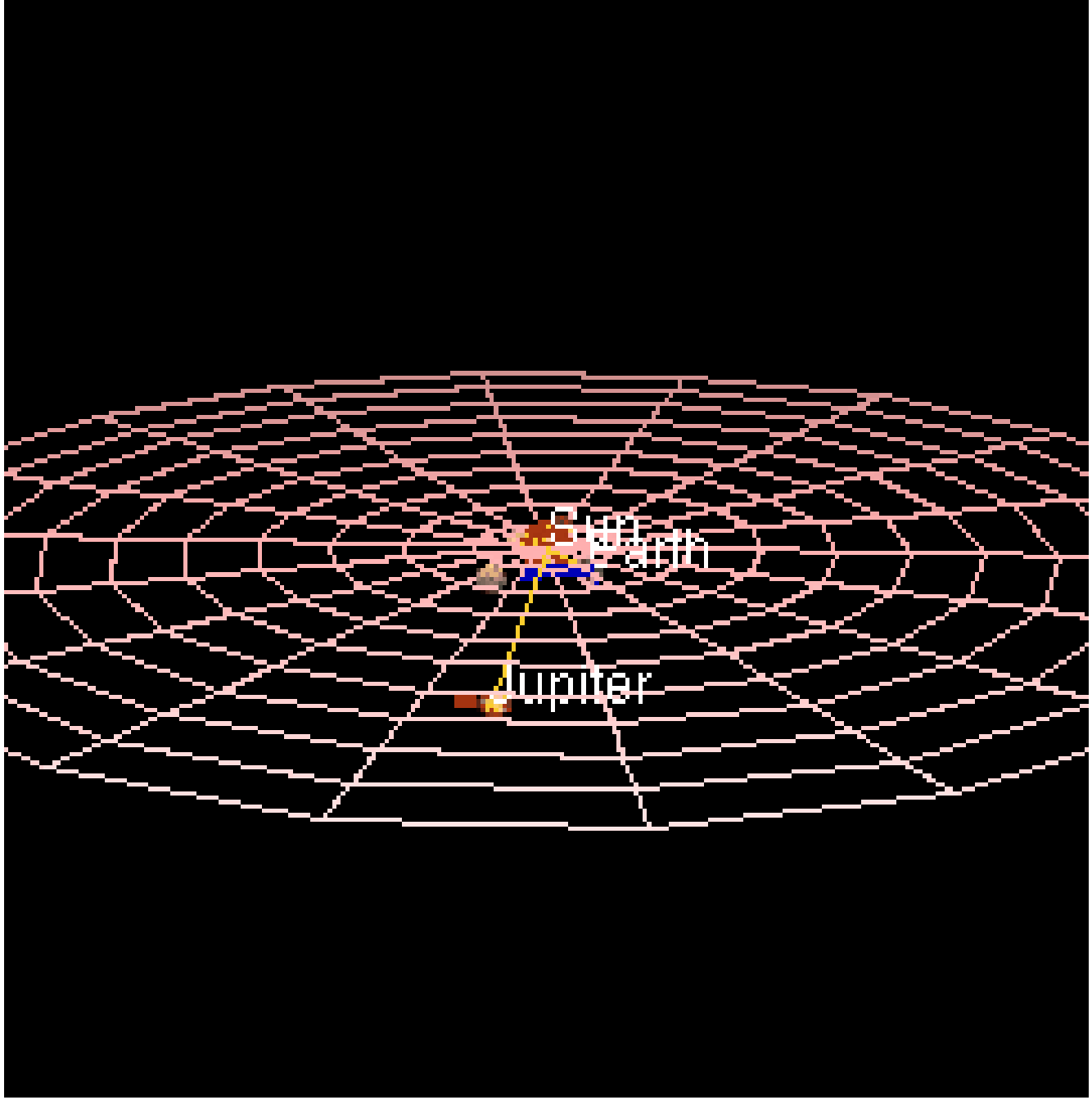
  Fourier analysis of X-rays from non-flaring Sun!
  Not done before [A. Veronig, 2013]

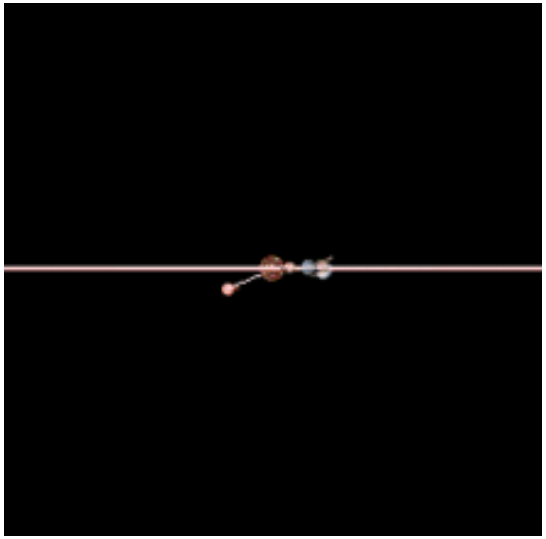
  >> visible Sun's modulation (11yr) ≈ 10^{-3}
  >> ≥ 50eV solar modulation → 10^{2}

  } **~10^{5}**

Corona mystery!

Thank you!





http://images.search.yahoo.com/images/view?p=ecliptic+plane&back=http%3A%2F%2Fsearch.yahoo.com%2Fcs%3Fei%3DUTF-8%26p%3Decliptic%2Bplane%26cap_type%3Dshortcuts%253A%252Fconcept%252Fmlprisma%252Cshortcuts%253A%252Fus%252Ftag%252Fother%252Fwiki%26fr%3Dcsc_answers_us&w=795&h=543&imgurl=physics.uoregon.edu%2F%7Ejimbrau%2FBraulmNew%2FChap06%2FFG06_05.jpg&size=47KB&name=FG06_05.jpg&rcurl=http%3A%2F%2Fweb.hallym.ac.kr%2F%7Ephysics%2Fcourse%2Fa2u%2Fplanet%2Fecliptic.htm&rurl=http%3A%2F%2Fweb.hallym.ac.kr%2F%7Ephysics%2Fcourse%2Fa2u%2Fplanet%2Fecliptic.htm&type=&no=2&tt=111&oid=71ea6080385d092a23fe8c5768b5ae9b&tit=Ecliptic+Plane&sigr=11v819i73&sigi=11pphlcuq&sigb=14qj7h2vi&fr=csc_answers_us

Back-up slides

Sun's external irradiation ($L_\odot = 3.8 \cdot 10^{33}$ erg/s =1)

- CMB ~10^{-14} (~$3 \cdot 10^{20}$ erg/s ≈ 1 SFU) ✓

- **DM** **~10^{-8}** (~ $4 \cdot 10^{25}$ erg/s) **+ gravitational focusing?**

~ 10^{30} – 10^{32} erg/s

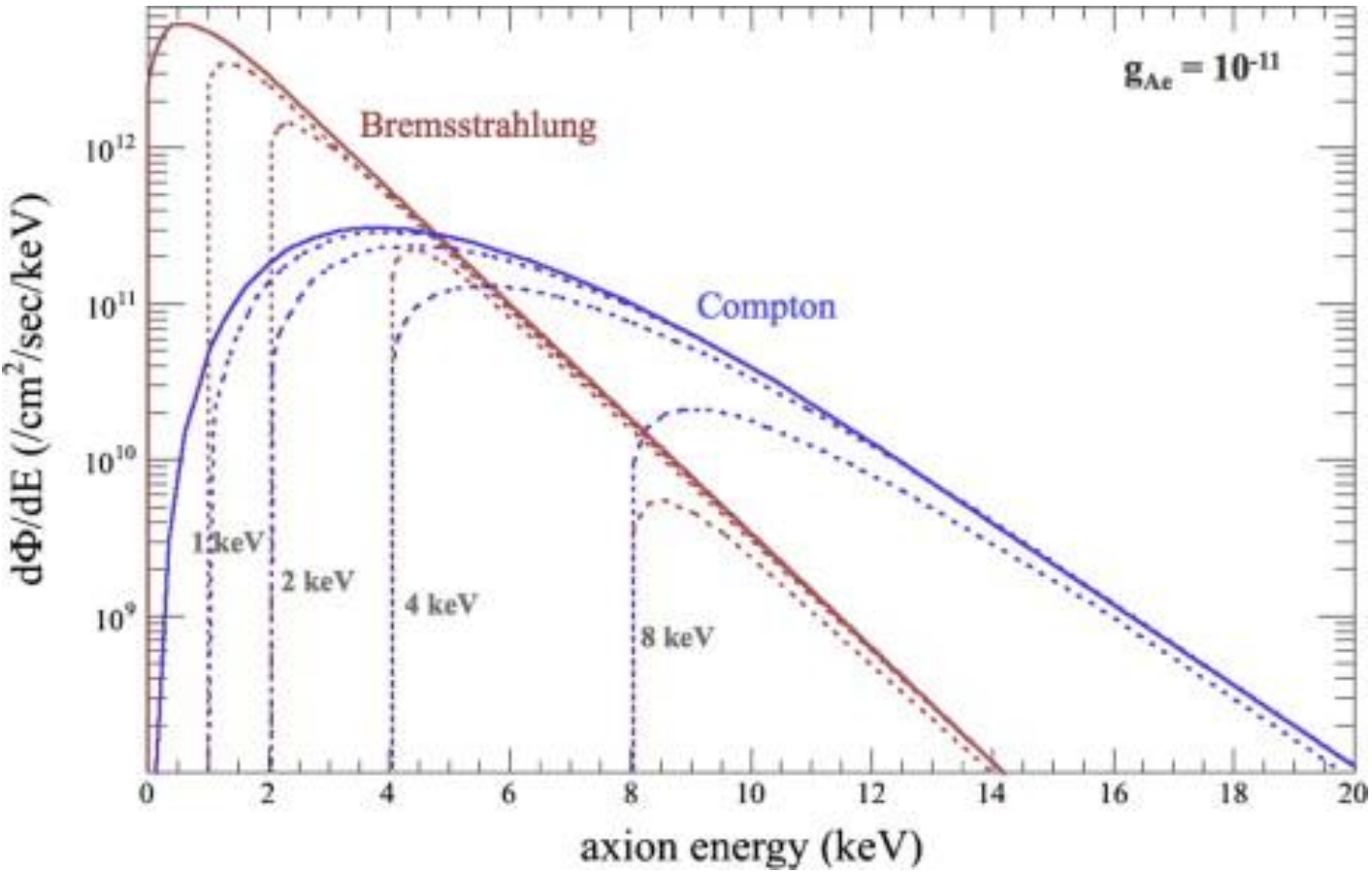
Galactic / Solar axions

K. Arisaka, … R. D. **Peccei**, …

2013

2003

KK-axions:
Large Extra Dimensions



Energy spectrum **solar axion flux** from Bremsstrahlung (**red**) + Compton (**blue**).

K. Arisaka *et al*. / Astroparticle Phys. 44 (**2013**) 59;http://xxx.lanl.gov/pdf/1209.3810.pdf

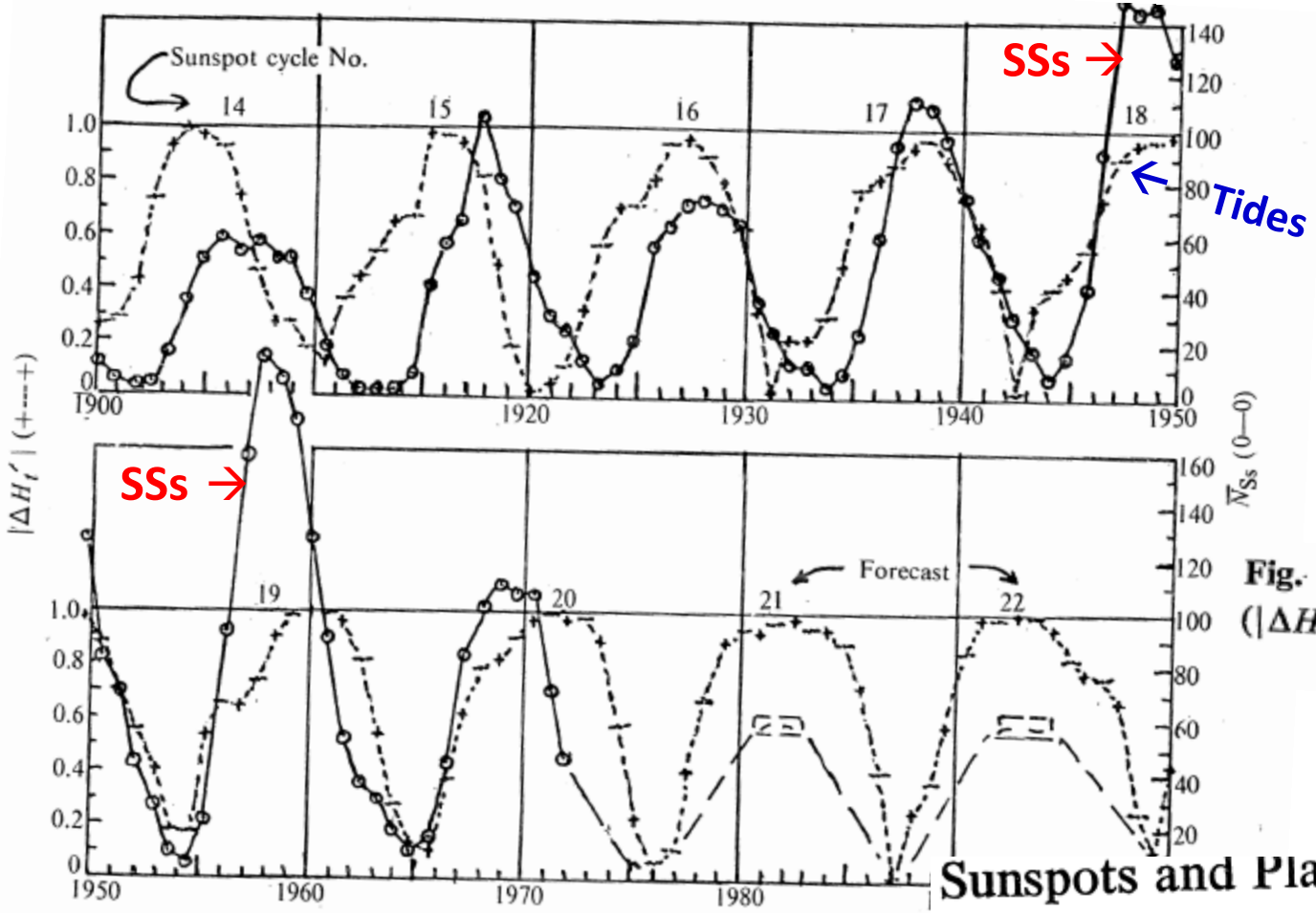


Fig. 1 Tidal height fluctuation ($|\Delta H_t'|$) and sunspot number ($\bar{N}_{Ss}$) twentieth century.

Sunspots and Planets

Most current literature on solar activity assumes that the planets do not affect it, and that conditions internal to the Sun are primarily responsible for the solar cycle. Bigg[1], however, has shown that the period of Mercury's orbit appears in the sunspot data, and that the influence of Mercury depends on the phases of Venus, Earth, and Jupiter. These four are the "tidal planets"; their relative tidal heights raised on the Sun are Mercury $1.15 + 0.65$, Venus 2.17 ± 0.04, Earth 1.00 ± 0.05, and Jupiter 2.28 ± 0.32. The ranges of values are due to the orbit eccentricities. No other planet raises a solar tide greater than 2% of the Earth's contribution. Here I discuss

Sunspot activity affected by positions of the Planets >>> planetary tides on the Sun vary In the same way as the sunspot variations.

K.D. Wood, Nature 240 (1972) 91

Earth-Venus conjections occur every 1.6 years

New manifestations of the dark Universe

Abstract:

Radiatively decaying massive exotica may be at the origin of astrophysical / cosmic observations in X-rays, e.g., diffuse emission, tails and the recent precision measurements by the *Planck* mission. At certain time windows of opportunity the expected signature of the dark cosmic radiation from point-like sources and/or dark matter streams can be enhanced due to gravitational lensing with as yet overlooked implications. Axions of the Kaluza-Klein type along with HS photons are suggestive examples.