Every day signatures for streaming invisible matter.

-dark matter + missing antimatter mysteries-

Konstantin Zioutas

University of Patras / Greece

...'crisis' in the DM community. NATURE 3rd Oct 2018

Collaboration with:

- ***S. Bertolucci, E. Eleftheriou, H. Fischer, W. Funk, S. Hofmann, M. Maroudas, Y.K. Semertzidis, ...***

[further reading]

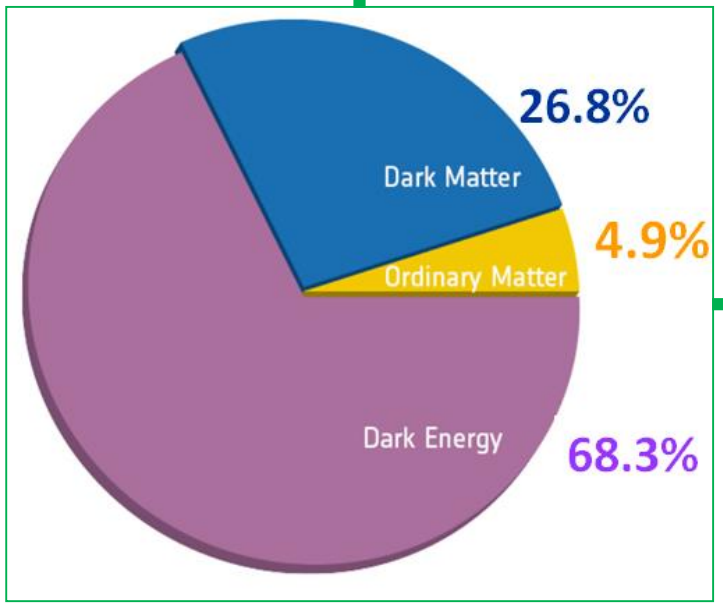
- S. Bertolucci, K. Z., S. Hofmann, M. Maroudas, *The Sun + its Planets as detectors for invisible matter,* Phys. Dark Universe 17 (**2017**) 13; https://doi.org/10.1016/j.dark.2017.06.001 .
- H. Fischer, X. Liang, Y. Semertzidis, A. Zhitnitsky, K. Z., *New mechanism producing axions in the AQN model and how CAST can discover them*, Phys. Rev. D98 (**2018**) 043013; 10.1103/PhysRevD.98.043013
- H. Fischer (CAST Collab.): CAST Proposal Addendum to SPSC, *Search for Axions + Chameleons with CAST; Axions from DM & AQNs, Solar Axions & Chameleons,* http://cds.cern.ch/record/2641282 (2/10/**2018**)

Discrete Symmetries in Particle, Nuclear & Atomic Physics + implications for our Universe

ECT* - https://indico.ectstar.eu/event/25/ Trento, Italy

8/10/2018 – 12/10/2018

"All we know is dark matter is well hidden" ✓



→ But, …

✓ Dark sector signatures are not expected!

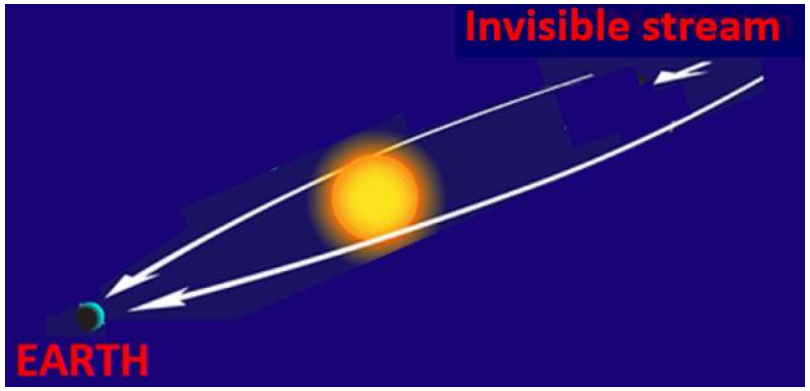
Within known physics

Unexpected Solar / terrestrial behavior?

? Insisting anomalies / mysteries in the solar system: ***the unnoticed manifestation of the dark Universe*** ?

The working hypotheses:

- Planetary / solar gravitational focusing of streams of non-relativistic "*invisible massive particles*"
- The focused invisible streaming matter interacts *"strongly"* with solar / planetary atmospheres
  >> no screening, plasma-effects, …
- Enhancement during repeating stream alignments



Gaia mission[&)]: **SKY RIVERS**

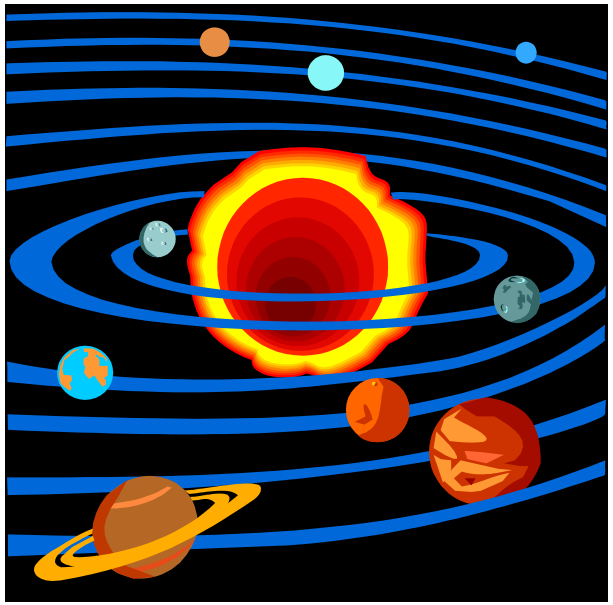
[&)] E. Hand, Science, **4th Oct 2018**
doi:**10.1126/science.aav6054**

Event time = $\Theta_{longitude}$

Search for planetary correlations

?

origin



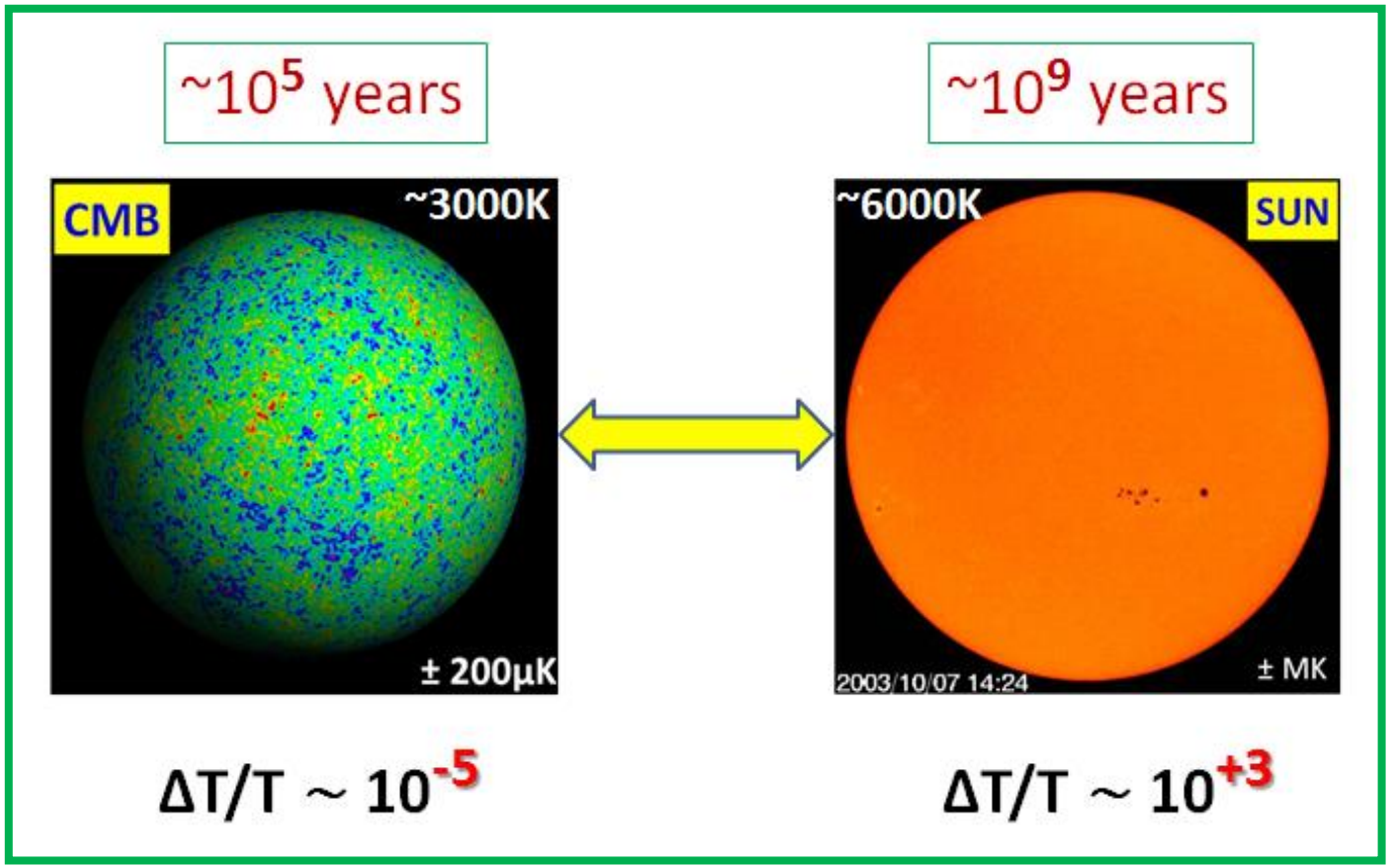
Wolf, 1859: *solar dynamics is partially driven by **planetary tides**.*

- *a plausible physical mechanism has not been discovered yet…*
- *the planetary tidal forces are too small to modulate solar activity..*

N. Scafetta, J. Atm. & Sol.-Terr. Phys. 81–82 (**2012**) 27

But, the 11 years solar cycle = Jupiter-Earth-Venus synod

UNIVERSE **SUN**



The multifaceted Sun →

Solar Flares

1859 - ***unpredictable mysteries***

one of the most important challenges in solar physics [1]

Solar Corona

1939 - ***one of the fundamental problems in space science*** [2].

Ionosphere

1937 - ***a long-standing unexplained annual anomaly*** [3]: ρ_e(DEC) > ρ_e(JUNE)

Remain unanswered too long!

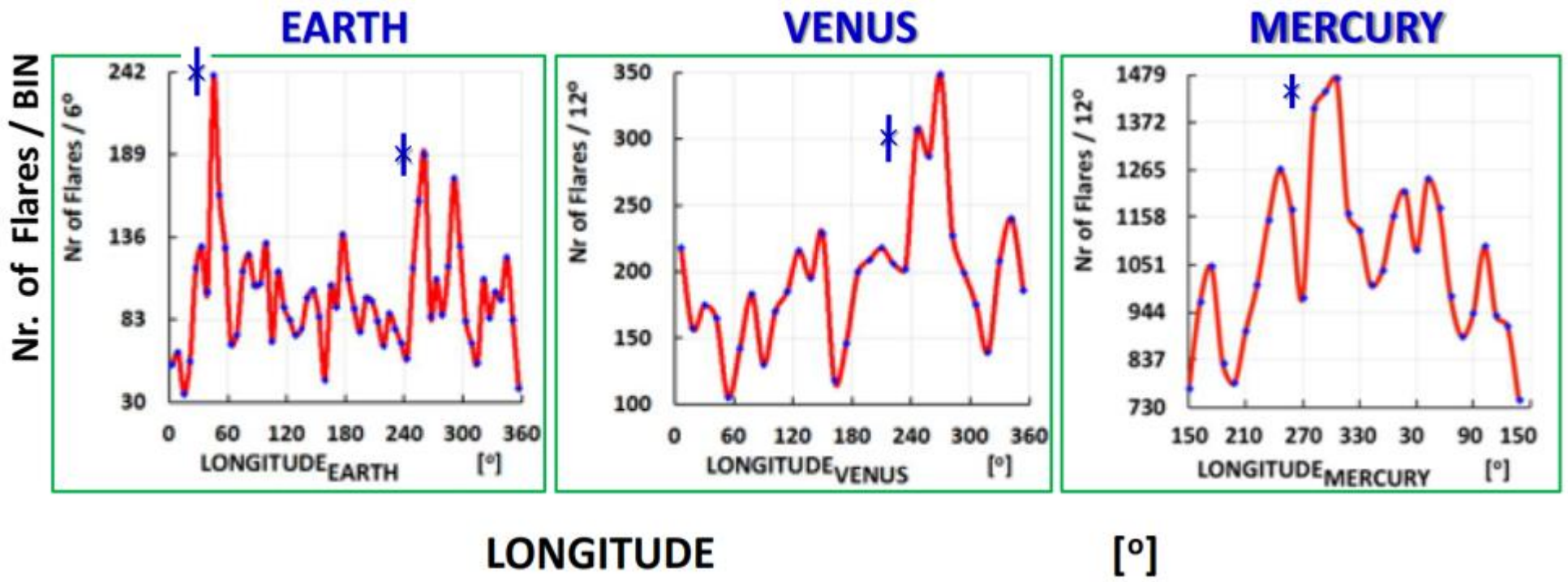
MBPs + Solar Elemental Composition + 10.7 cm + GMF + Sunspots …

[1] V. Polito *et al.*, *ApJ* 816 (**2016**) 89 ; https://doi.org/10.3847/0004-637X/816/2/89

[2] J.A. Klimchuk et al. , PASJ (**2017**); https://arxiv.org/abs/1709.07320

[3] E.V. Appleton, Proc. Roy. Soc. London A162 (**1937**) 451; http://rspa.royalsocietypublishing.org/content/162/911/451 .

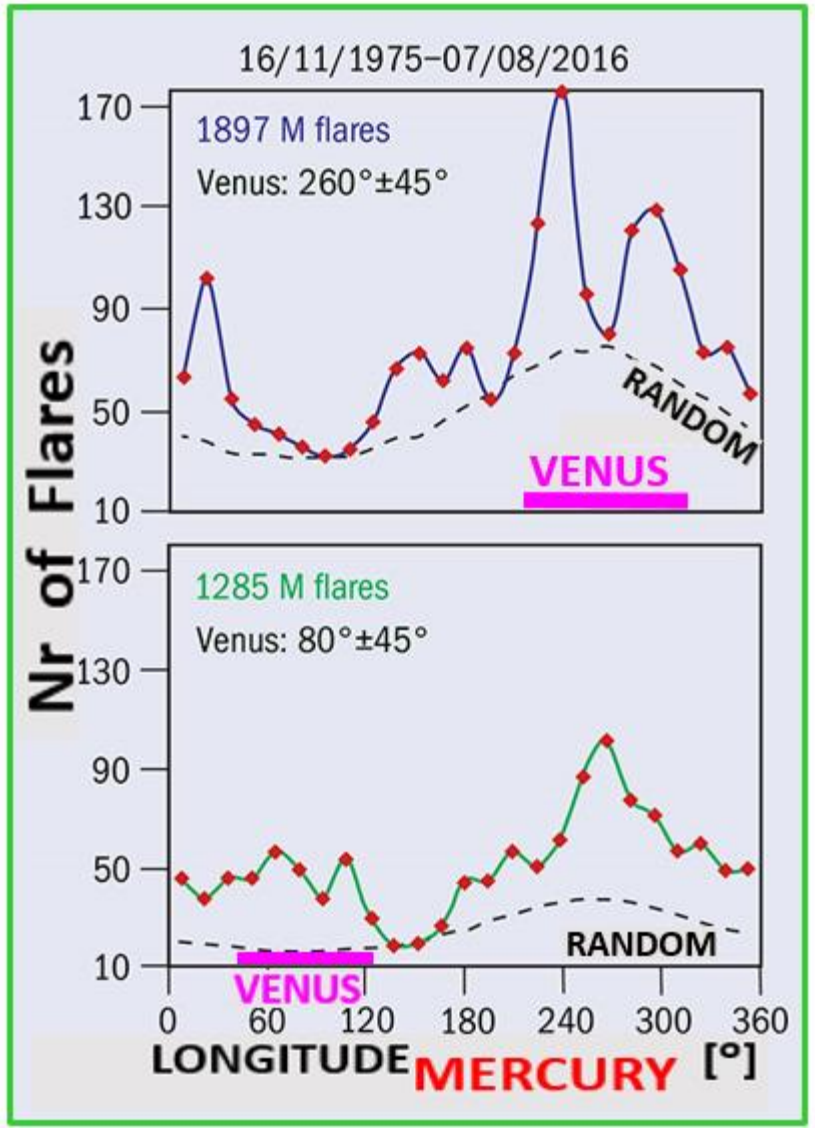
Solar Flares: *planetary relationship*



M.J. Aschwanden's data!

CERNCOURIER

VOLUME 57 NUMBER 8 OCTOBER 2017 p. 7

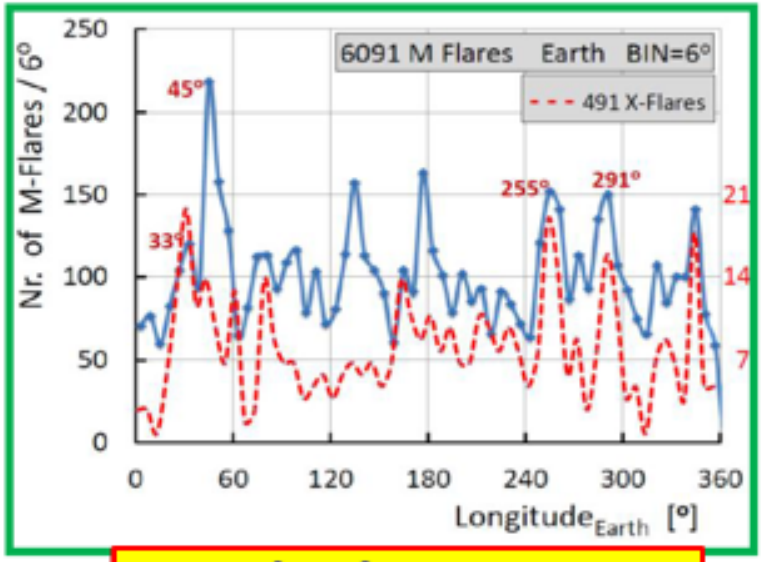


MERCURY ⊗ VENUS

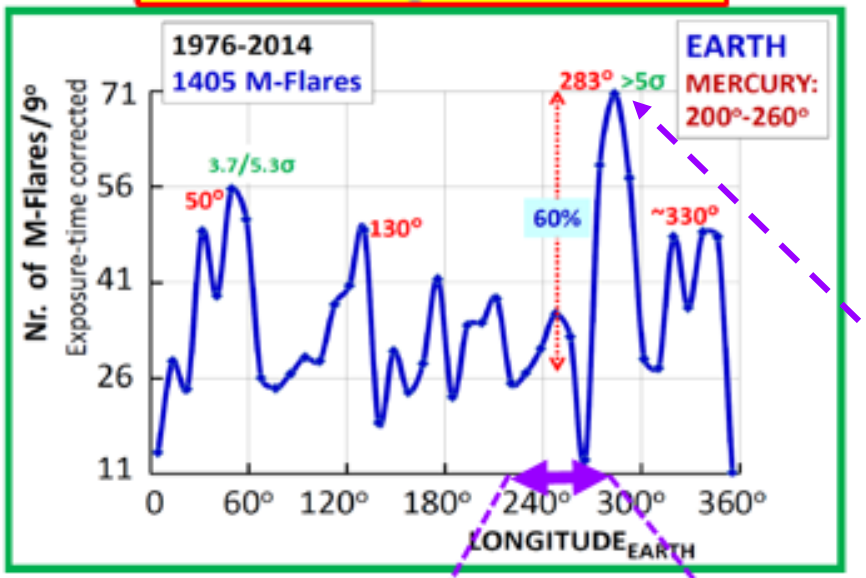
M-class solar flares

- **EXCESS** above random **>45%**
  ➔ **dominating planetary impact** ➔
- **NARROW PEAKS =/=> tidal forces**
- **Planetary correlation of the active Sun**
  - streams

http://cerncourier.com/cws/article/cern/69886



Longitude-EARTH =>



MERCURY

EARTH

EARTH ⊗ MERCURY

ALL M-Flares

1405 M-Flares
Mercury:
200°-260°

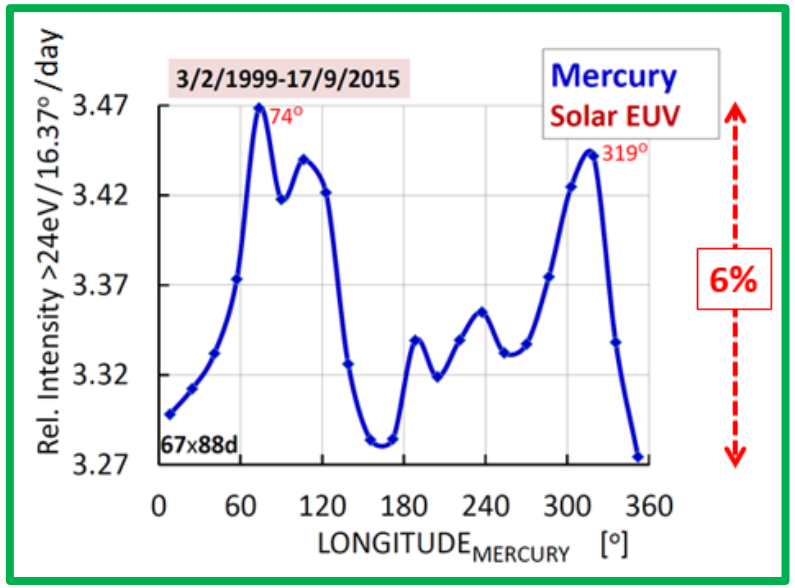
Stream from Galactic Centre's mega-BlackHole?

Heliocentric longitude ≈ **266°** + TOF (Earth => Sun)

➔ **18th December**

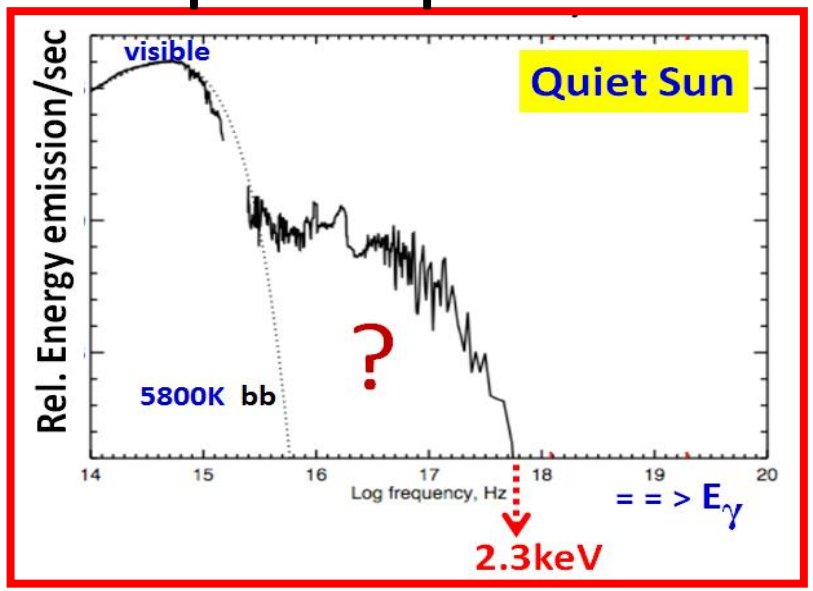
From whole solar disk:

Solar EUV: *planetary relationship*



LONGITUDE$_{MERCURY}$ [°]

Solar photon spectrum:



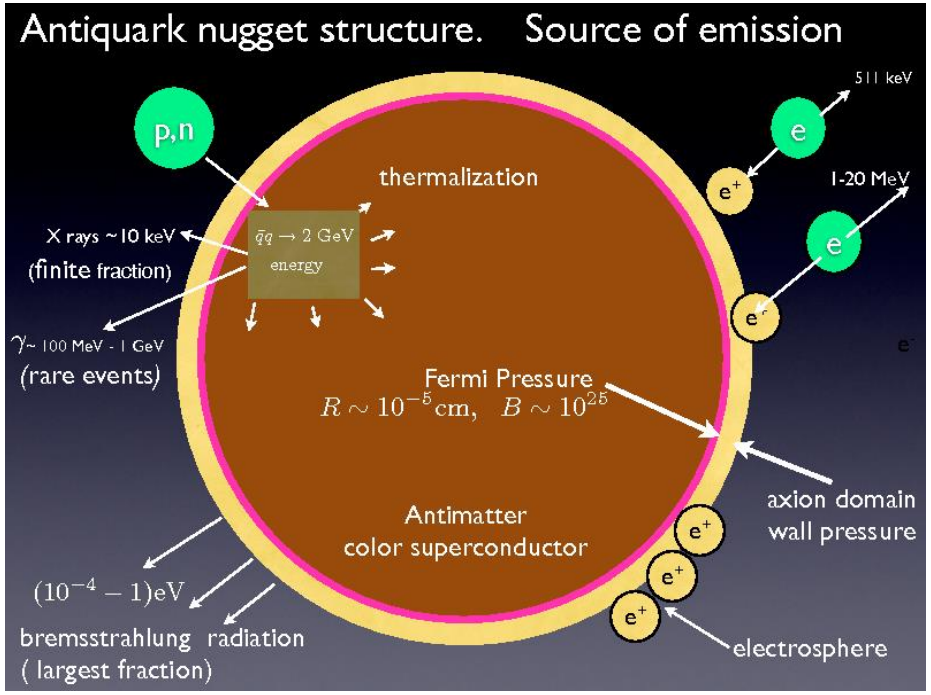
NEW MODEL …

*"The striking **EUV excess** of the quiet Sun is the manifestation of the **solar corona problem**."*

H.S. Hudson

Antiquark Nuggets → DM + missing antimatter + (much) more?

The ***slow speed streams of "strong" interacting invisible matter*** invoked in [1].



Collaboration work with **Ariel Zhitnitsky**

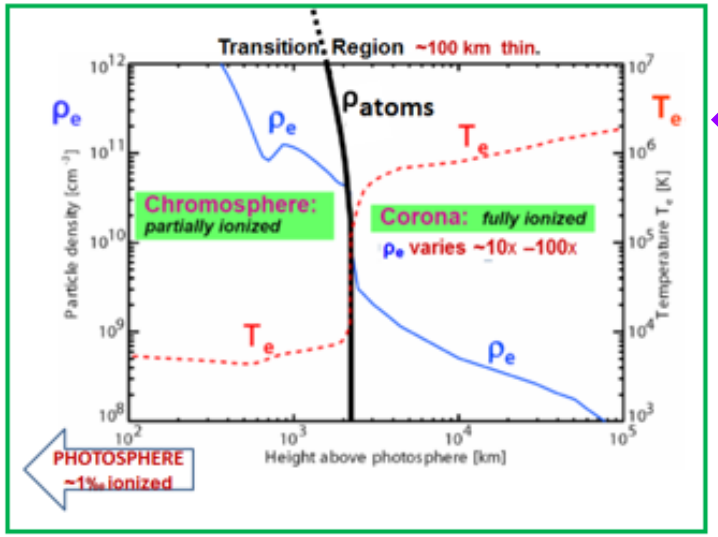
N. Raza, L. van Waerbeke, A. Zhitnitsky, *Solar Corona Heating by the AQN DM*, arXiv:1805.01897(**2018**) *+ ref's therein*

Sun / Ionosphere mysteries:

- **Corona heating source?**
  - *unexpected EUV*
- **Thin Transition Region:**
  - *how?*
- **Flares:**
  - energy source / trigger

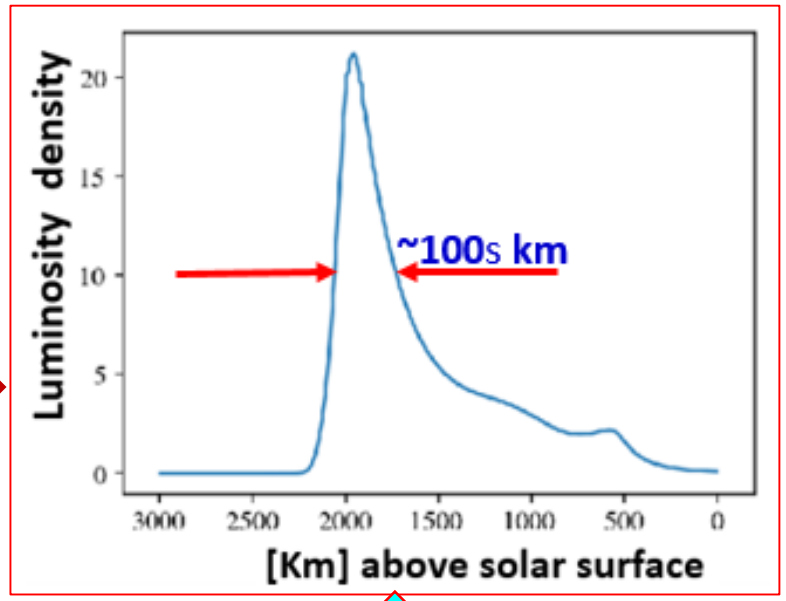
[1] S. Bertolucci, *etal.*, *The Sun + its Planets as detectors for invisible matter*, Phys. Dark Universe 17 (**2017**) 13; https://doi.org/10.1016/j.dark.2017.06.001

Chromosphere ⇔ Corona



← Observation

Simulation →



AQNs:

- ***the ~100 km thin Transition Region*** (TR)
  - explained!
- **Defragmantation + domain wall axions:**
  new relativistic cosmic axions from Earth / Sun

N. Raza, L. van Waerbeke, A. Zhitnitsky, *Solar Corona Heating by the AQN DM*, https://arxiv.org/abs/1805.01897 (**2018**)

Axions from AQNs:

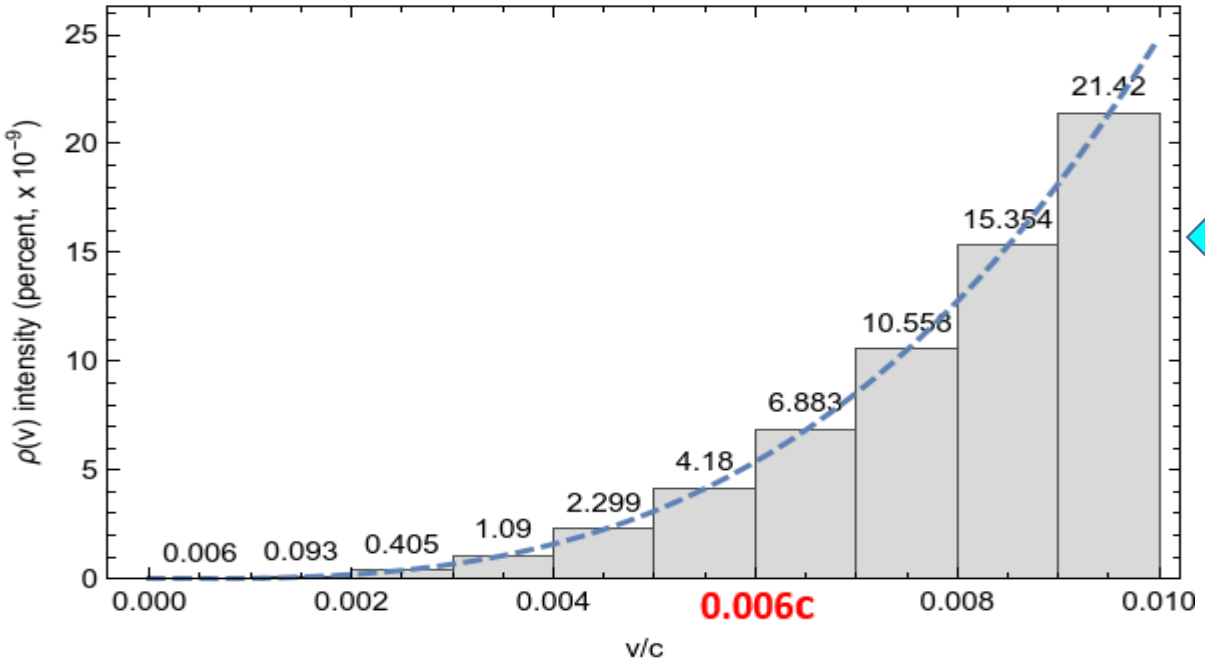
H. Fischer, X. Liang, Y. Semertzidis, A. Zhitnitsky, K. Z., Phys.Rev.D98(**2018**)043013;
https://doi.org/10.1103/PhysRevD.98.043013

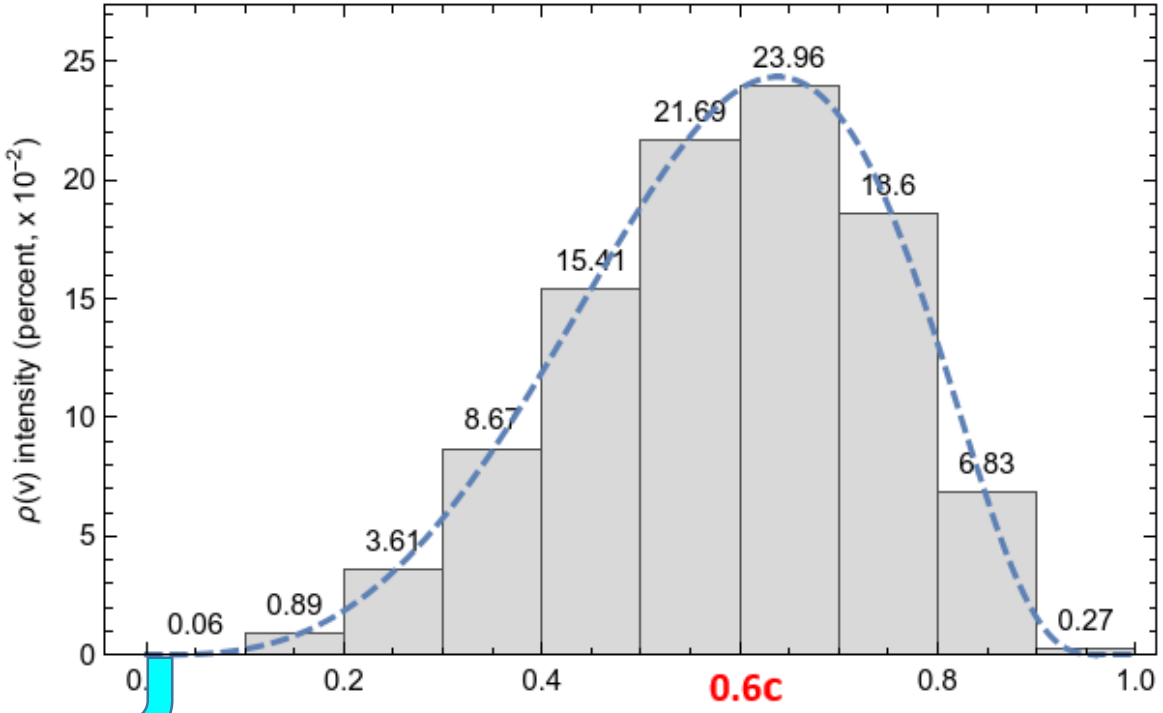
A new detection method for

- **DM + Matter⇔Antimatter asymmetry**

➔ **CAST** proposal to CERN**!**

FLARES: DM axion trigger





The normalized axion spectrum ρ(v) *vs*. v/c

New DM axion component

See also:

X.Liang,A.Zhitnitsky,https://arxiv.org/abs/1810.00673 **Oct 2018**

Beyond solar Flares & EUV

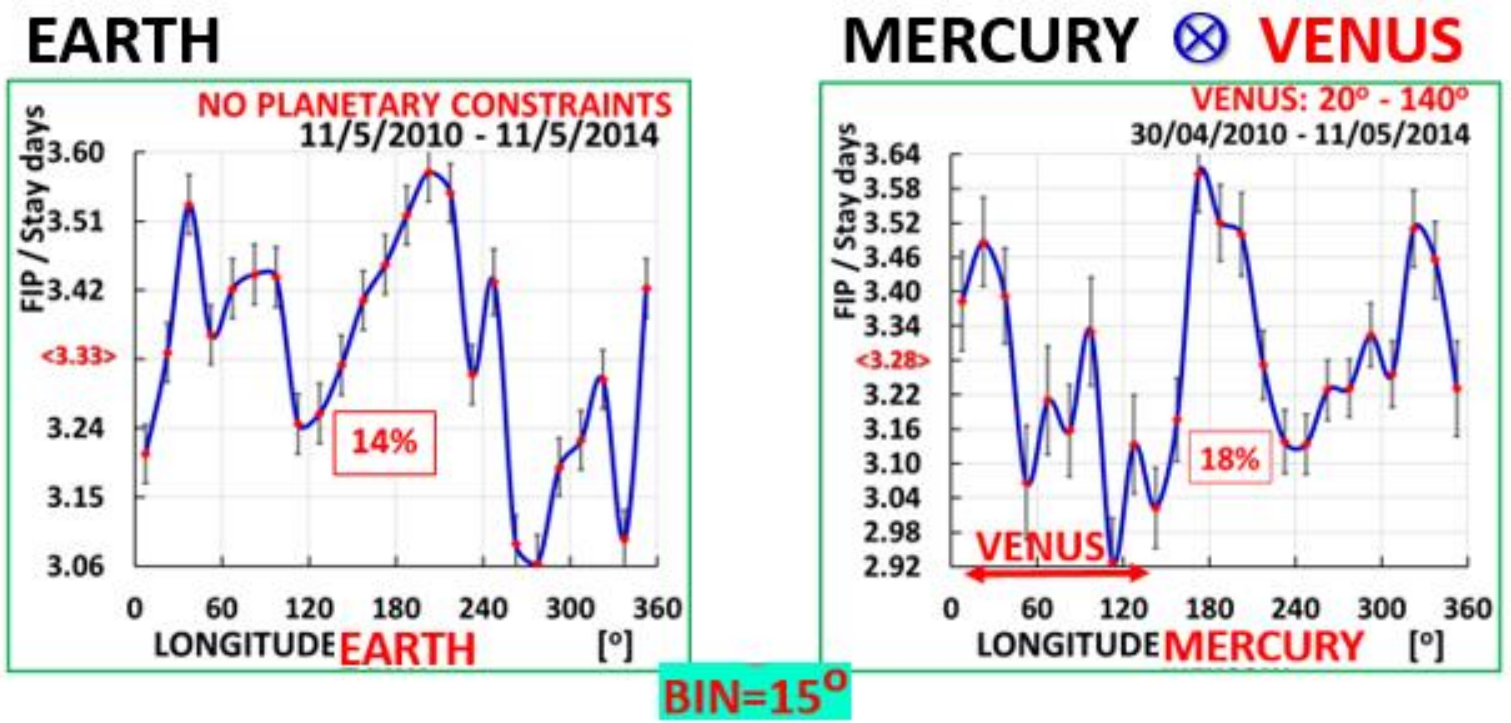
“Solar composition problem”

The mystery of the sun’s missing matter

“perhaps we are looking at the sun in the wrong way”

S. Palus, NEW SCIENTIST (**18th Oct. 2017**) https://www.newscientist.com/issue/3148/

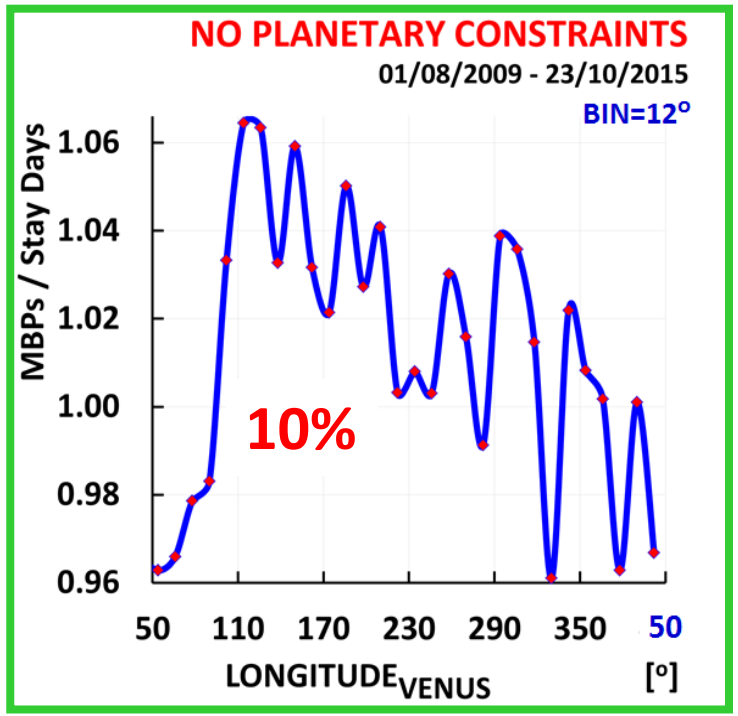
Solar-element-abundances:
planetary relationship **=> WHY?**



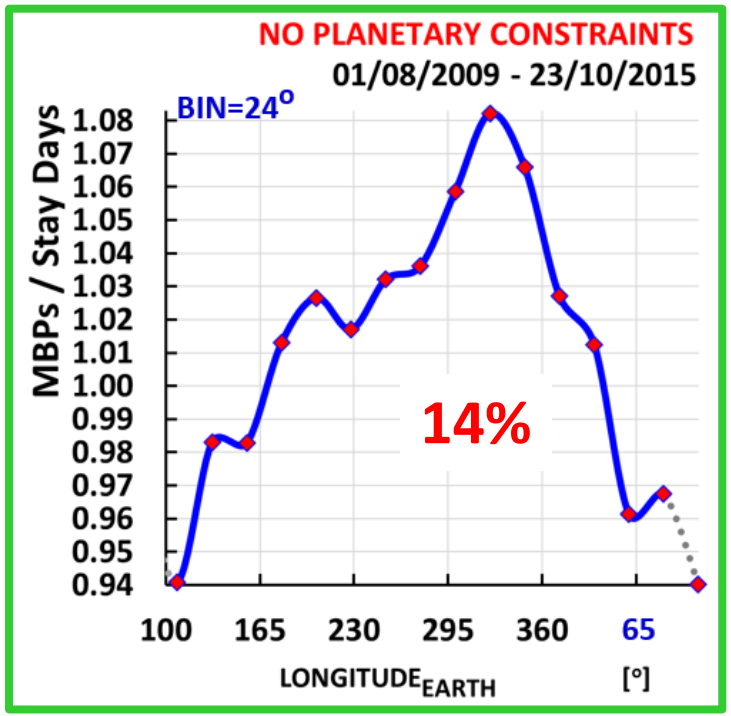
DH Brooks, D Baker, L van Driel-Gesztelyi, HP Warren, Nature Comm. 8 (**August 2017**) 183
https://www.nature.com/articles/s41467-017-00328-7

MBPs: *planetary relationship*

VENUS



EARTH



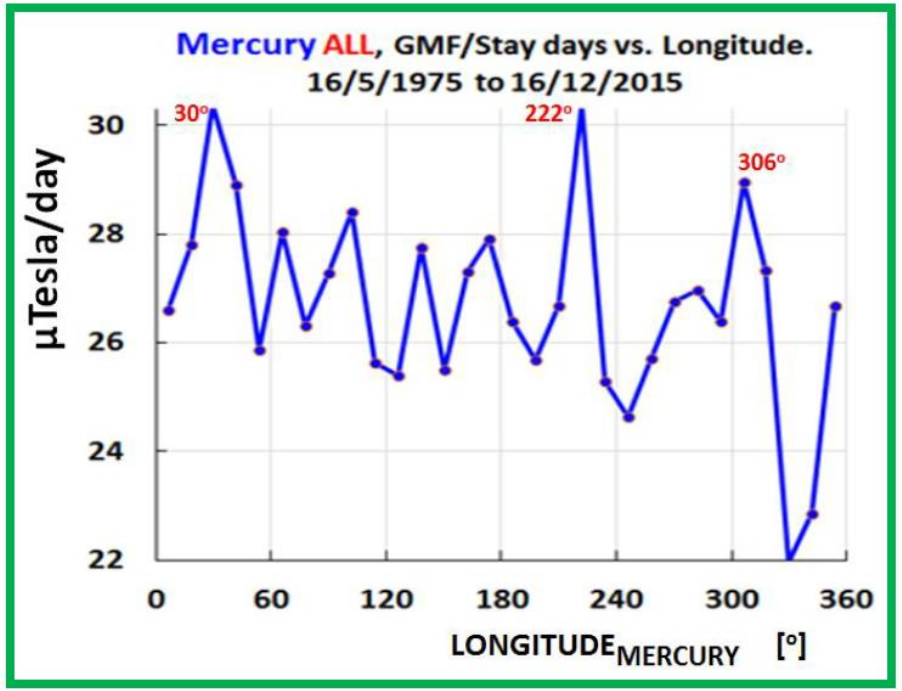
In collaboration with **Dominik UTZ** / Graz-Austria

D. Utz, *et al.*, https://arxiv.org/abs/1710.01678

Sun's **1975-2015**

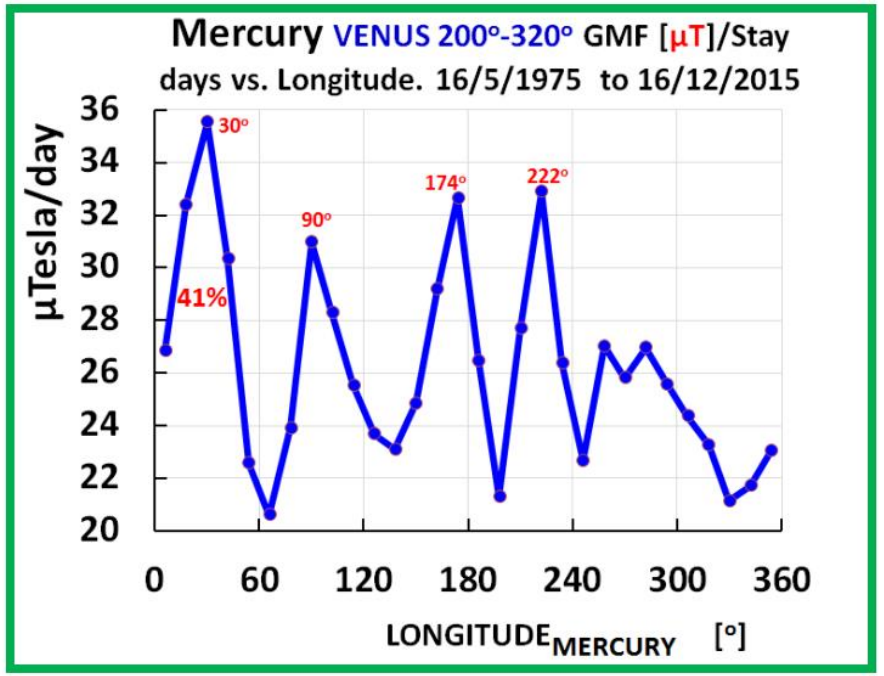
Global Magnetic Field

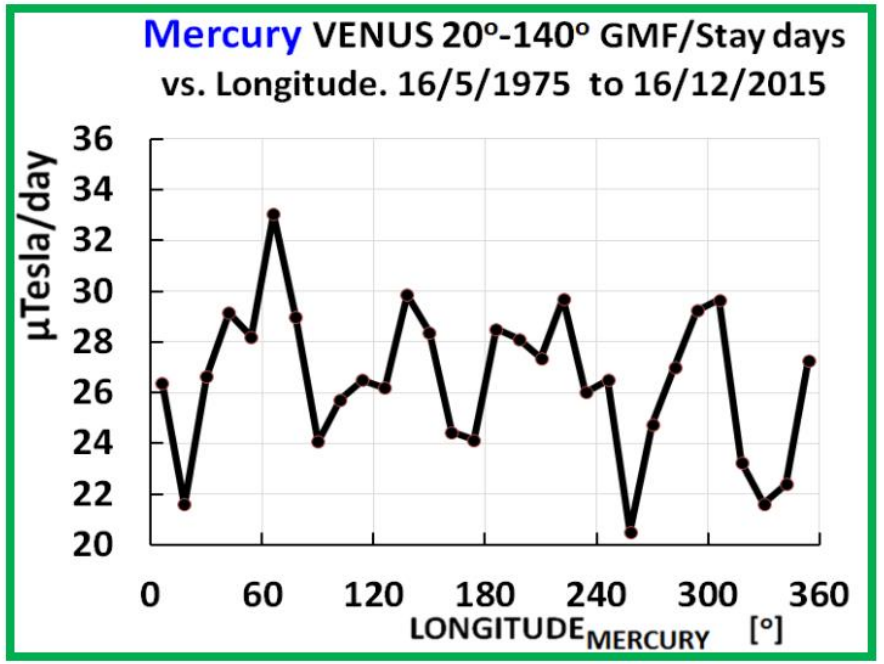
⊗ **Planets?** ⇨ **ORIGIN?**



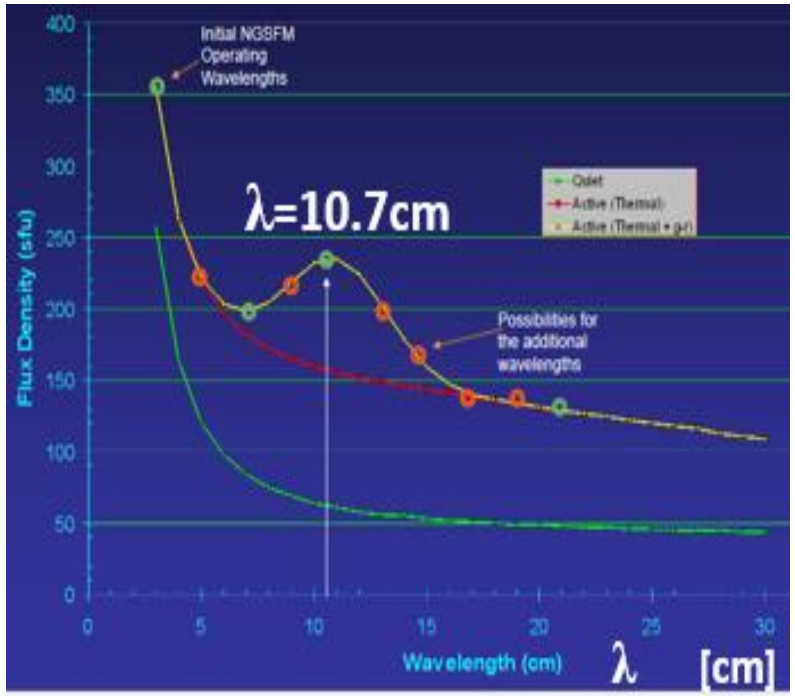
PRELIMINARY

Thanks Todd Hoeksema for the GMF-data

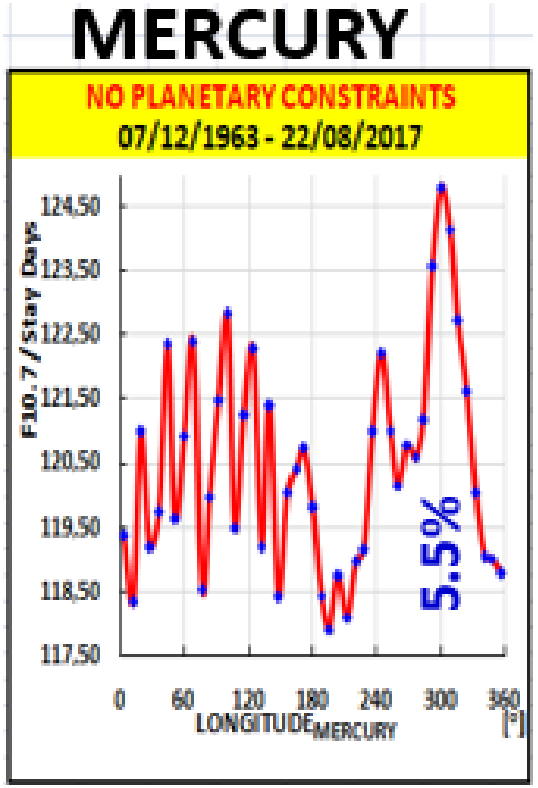


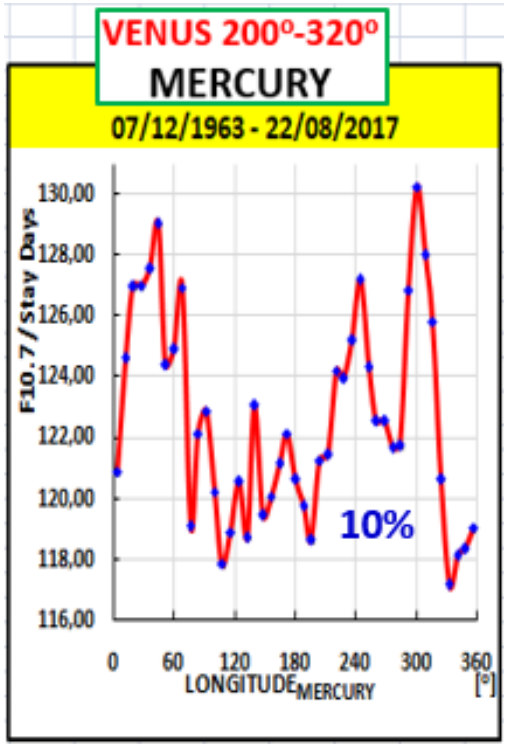


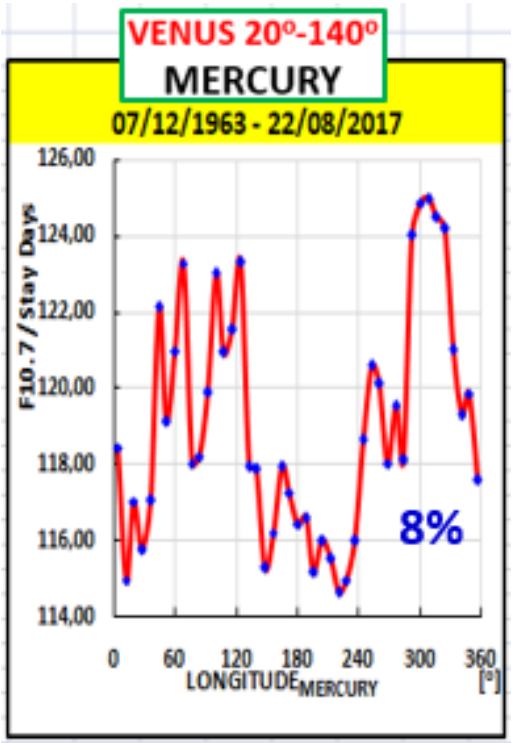
Solar spectrum (5-30 cm): *planetary relationship*



http://slideplayer.com/slide/3842825/





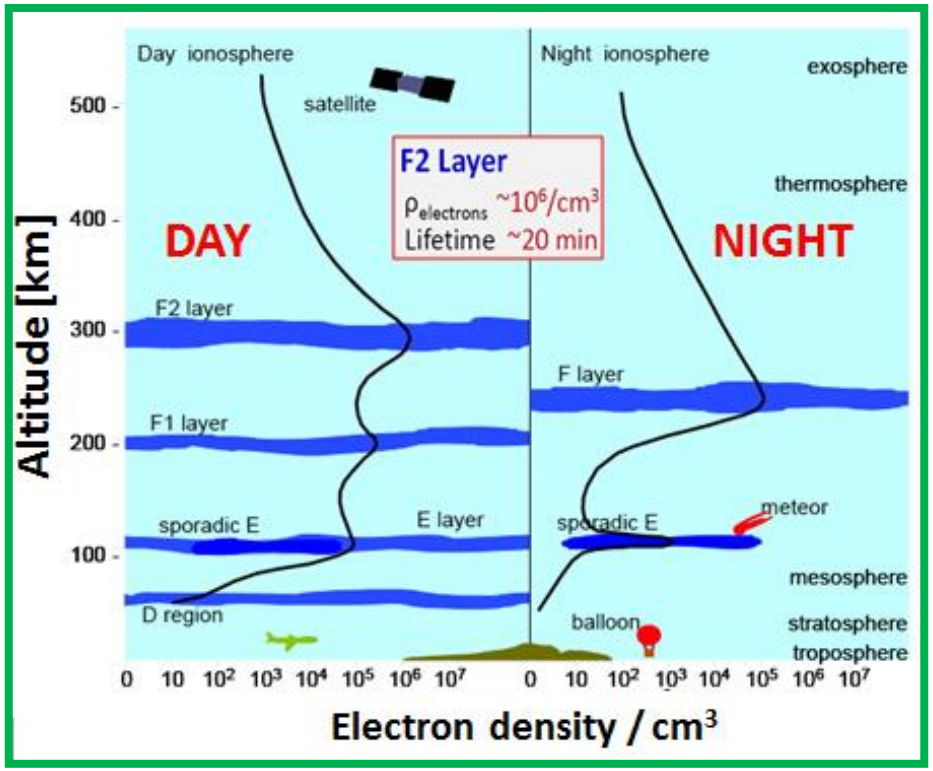


===== LONGITUDE$_{MERCURY}$ [°] ===== >

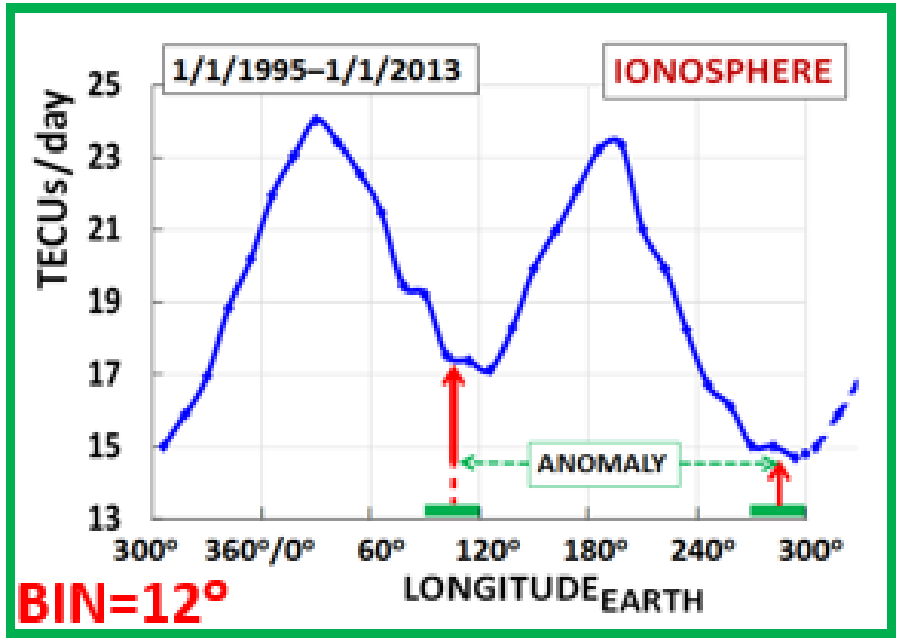
EARTH's IONOSPHERE: *planetary relationship*

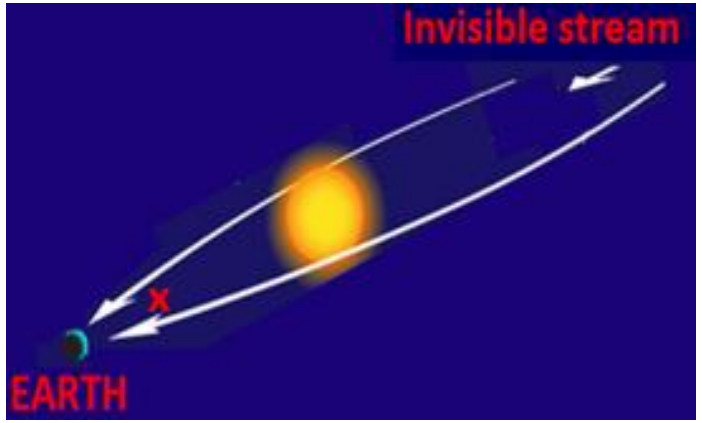
Anomalies lasting for some decades

>>> First obs' 1937/1938

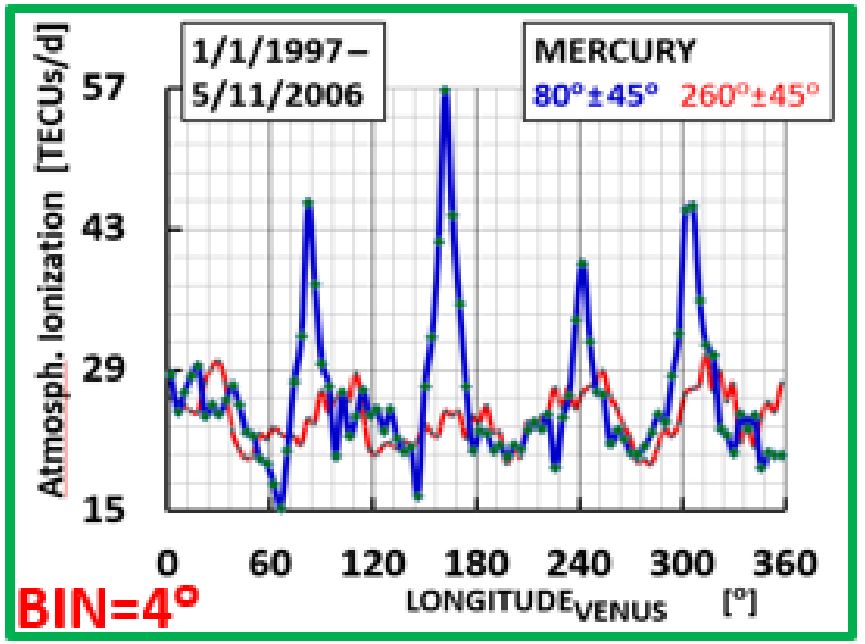


EARTH





VENUS ⊗ MERCURY



Stream(s) from G.C. mega-Black Hole?

Longitude ≈ **266°** **+** TOF (Earth **=>** Sun)

➔ **18th December**

Longitude ≈ **85°** **+** TOF (Moon **=>** Earth)

➔ **17th June, ..?.. NEW**

Helioseismology:

Solar radius = f(time)

Planetary relationship?

Solar Cycle Variations

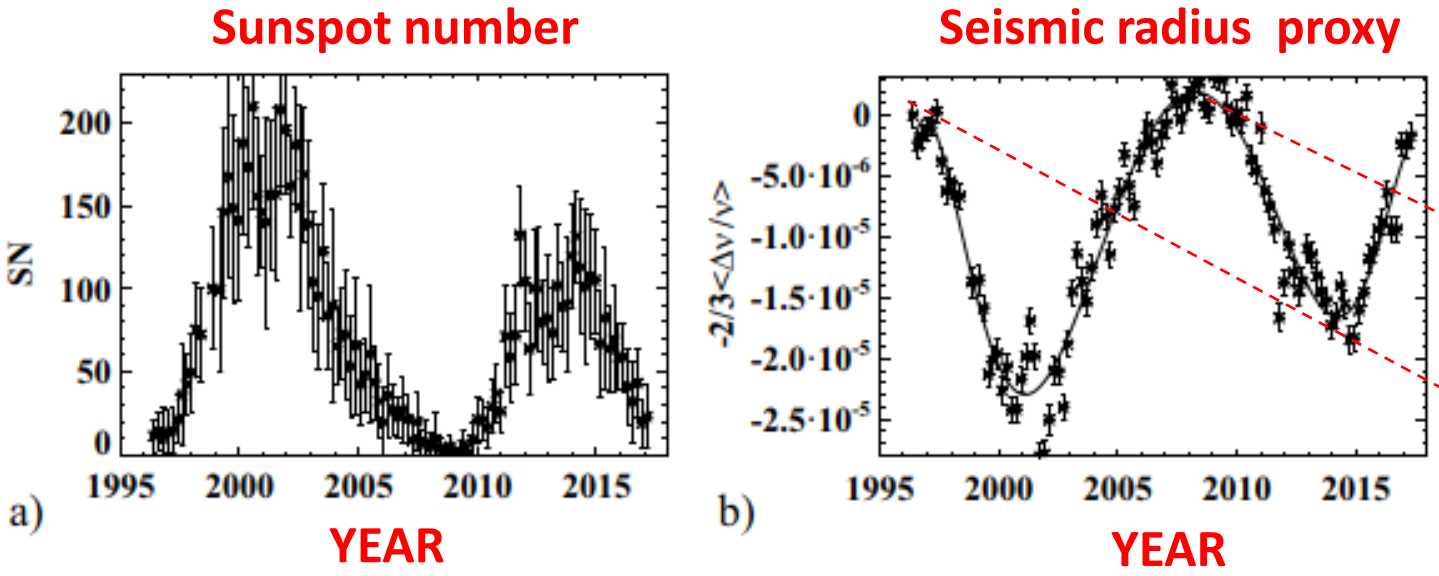


Figure 3: a) The sunspot number, SN, averaged for the 72-day periods corresponding to the intervals of the helioseismic analysis. b) Variations of the seismic radius proxy (Eq. 3) relative to the first measurement in 1996, as deduced from the analysis of the f-modes extracted from the MDI and HMI data from 1996 to 2017. The relative amplitude modulation of about -2.3×10^{-5} in Solar Cycle 23 and about -1.7×10^{-5} in Cycle 24 is clearly in anti-phase with the solar activity. The error bars show three standard deviations calculated using observational error estimates of the mean f-mode frequencies.

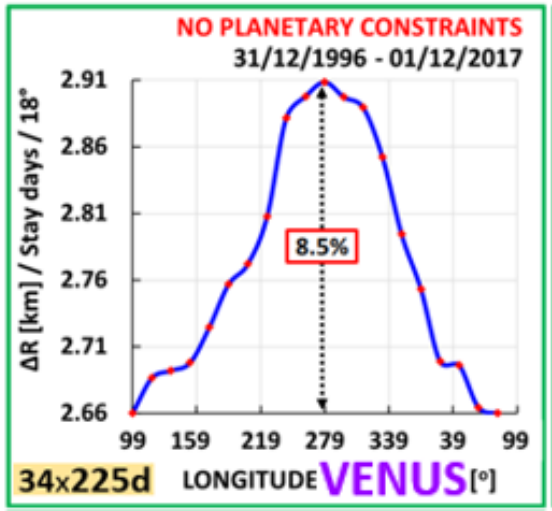
Earth's atmosphere shrinks during Solar Minima!

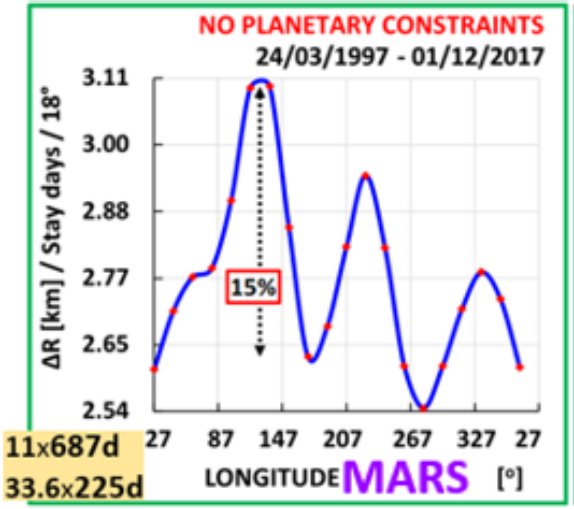
https://spaceweatherarchive.com/2018/09/27/the-chill-of-solar-minimum/ **Sept. 2018**

A. Kosovichev, J-P. Rozelot, J. Atm. Solar-Terr. Phys., 176 (**2018**) 21, https://doi.org/10.1016/j.jastp.2017.08.004 ; https://arxiv.org/abs/1804.05081

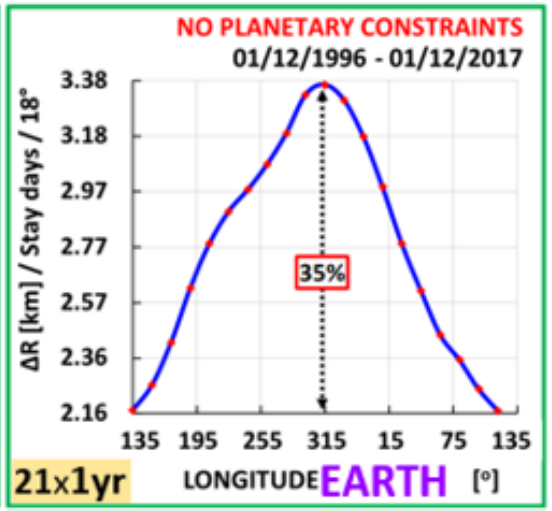
Measurements: Sun's Seismic Radius => 1996-2017 lin. Interp./72 d

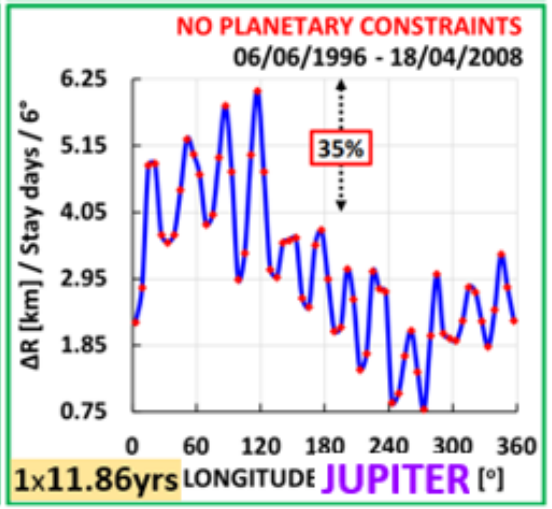
Observation





Calibration

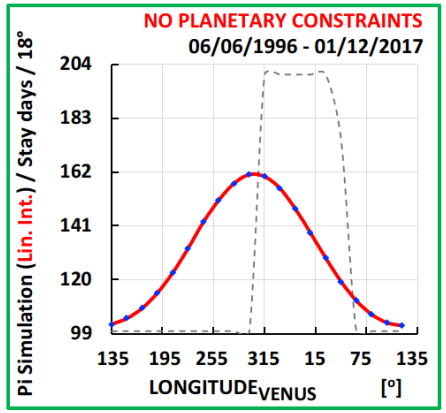


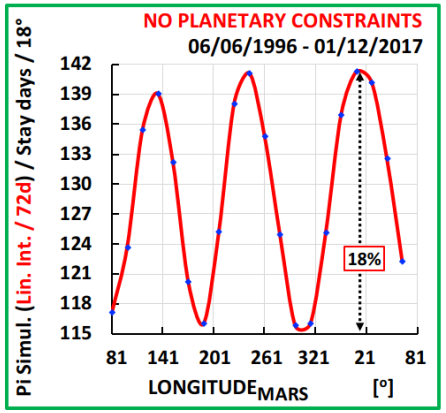


In collaboration with
Alexander Kosovichev / NJIT / USA

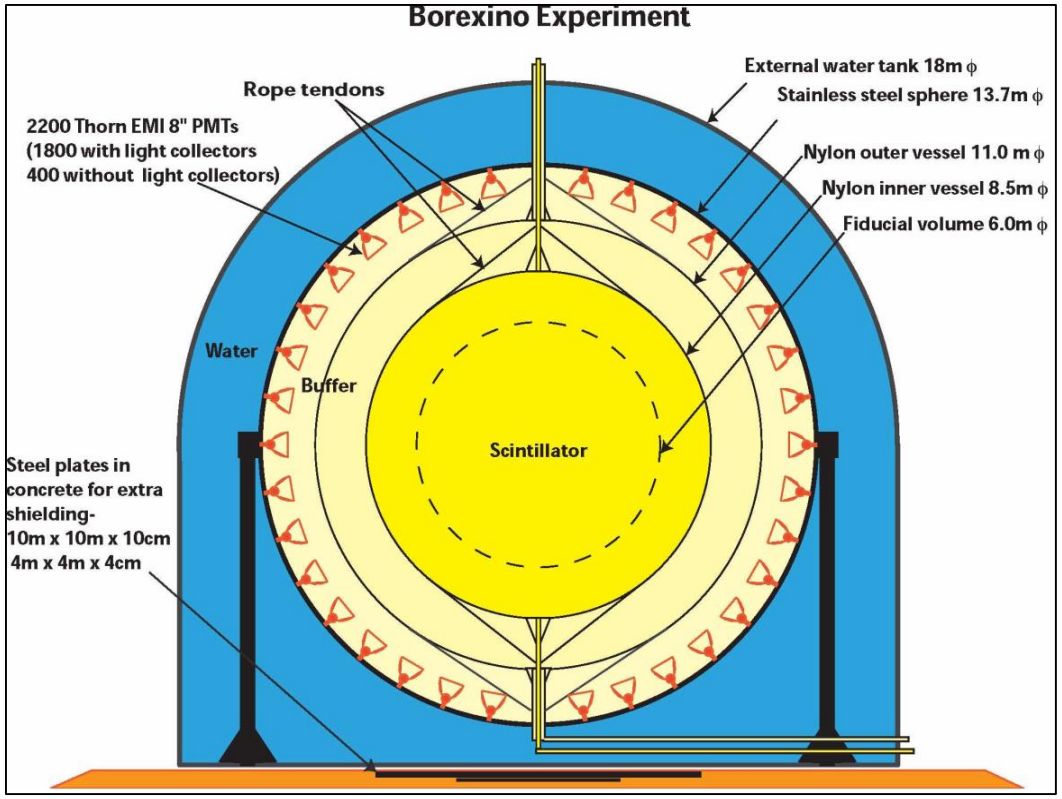
SIMULATION

Pi Distribution In VENUS (65 days width)





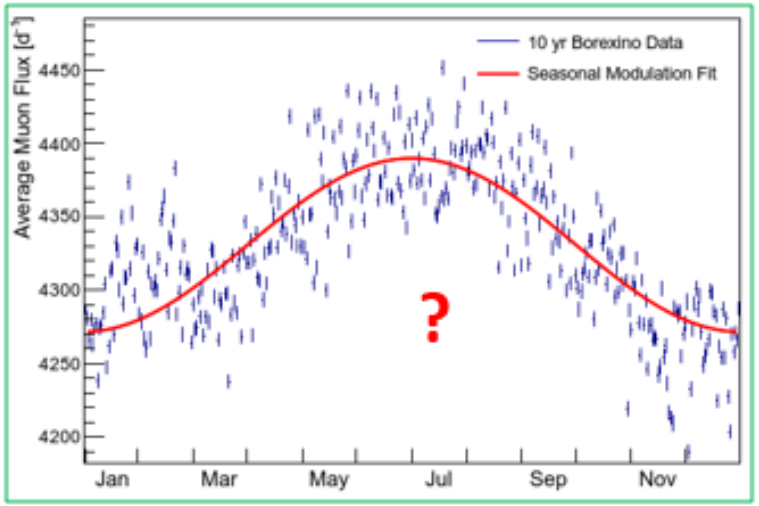
BOREXINO

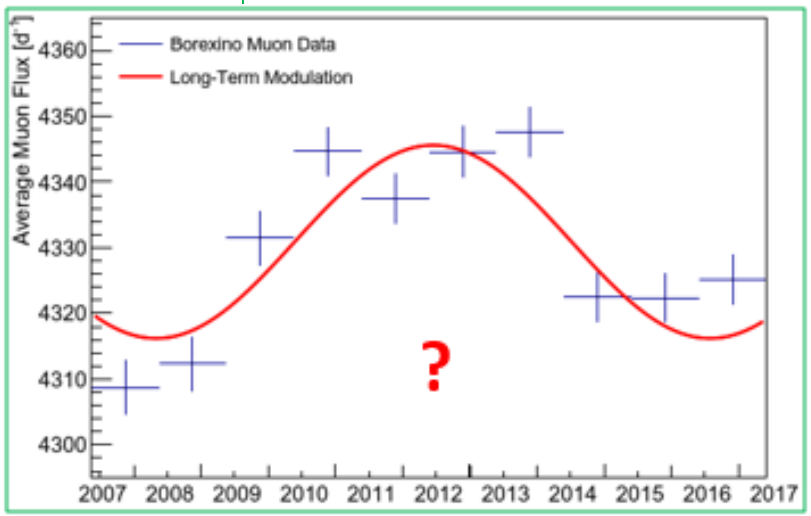

Borexino Experiment
Rope tendons
2200 Thorn EMI 8" PMTs
(1800 with light collectors
400 without light collectors)
External water tank 18m ϕ
Stainless steel sphere 13.7m ϕ
Nylon outer vessel 11.0 m ϕ
Nylon inner vessel 8.5m ϕ
Fiducial volume 6.0m ϕ
Water
Buffer
Scintillator
Steel plates in
concrete for extra
shielding-
10m x 10m x 10cm
4m x 4m x 4cm

Modulations of Cosmic Muons: 10 yrs **BOREXINO** *Data*

Planetary relationship?

Unexpected solar correlations @ *~TeV*





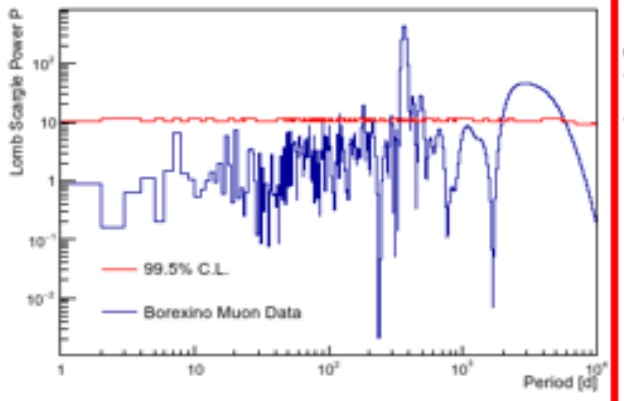
!

*"the **physical reason** for a correlation between the HE part of cosmic muon flux + the solar activity remains **unclear**."*

5th October 2018 → ***first working teleconference!***

https://arxiv.org/pdf/1808.04207.pdf

Modulations of Cosmic Muons: 10 yrs BOREXINO *Data*



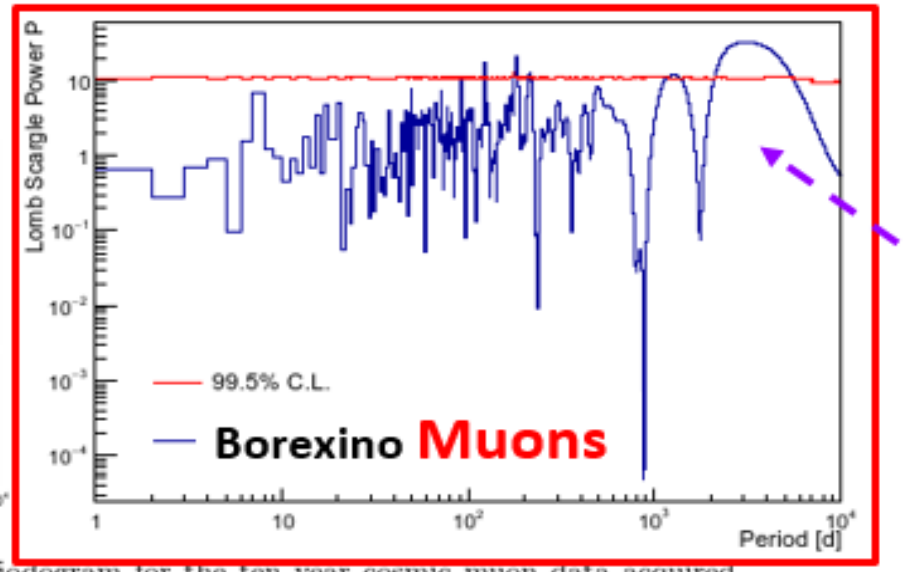


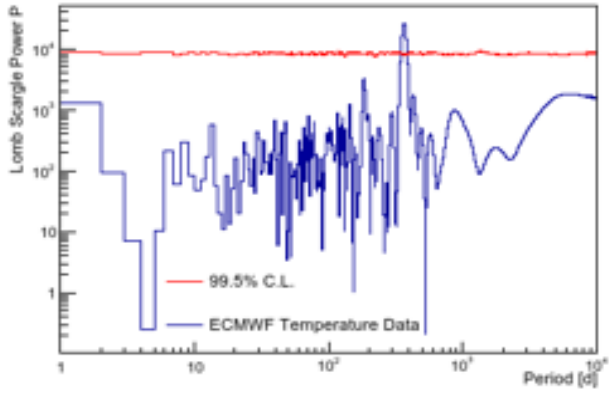
Figure 11. The *left* side shows the LS periodogram for the ten year cosmic muon data acquired with Borexino. The *right* side shows the LS periodogram of the cosmic muon data after the seasonal modulation was subtracted statistically. The red lines indicate the significance level of 99.5%.

~3000 days ≈ 8 years: **Origin?**

=> Earth-Venus 'super' synod?

Location of the peak:

~2550 d to ~3750 d



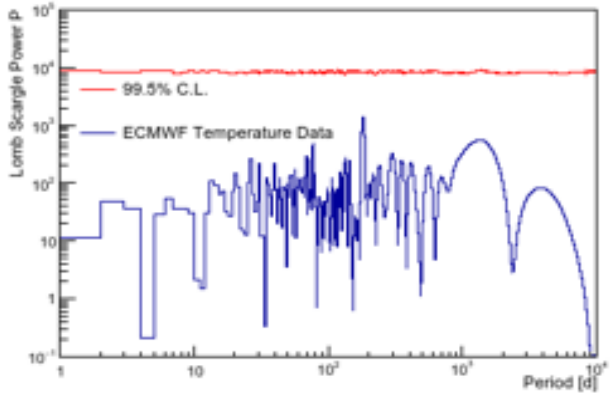
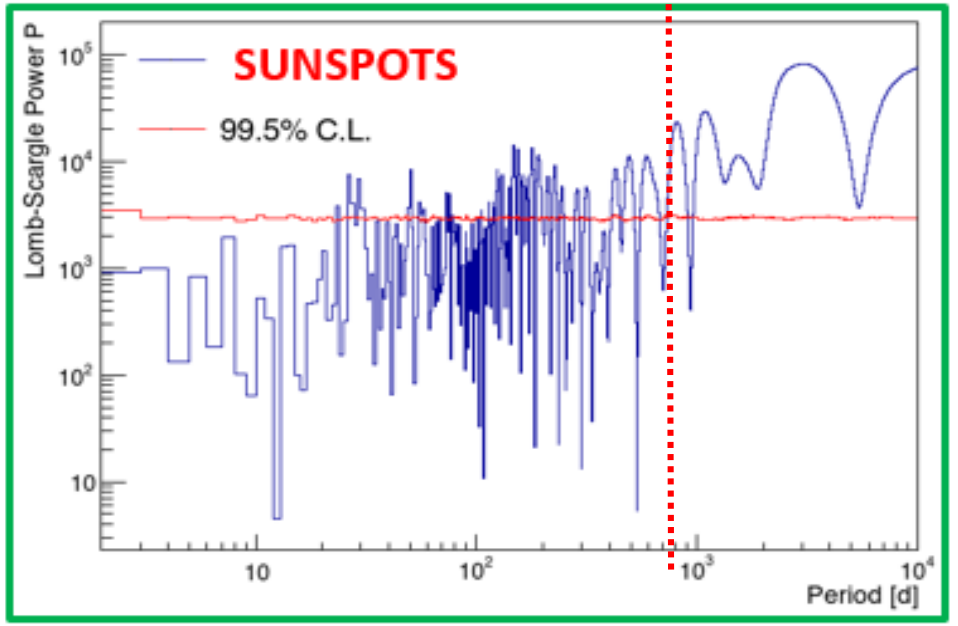


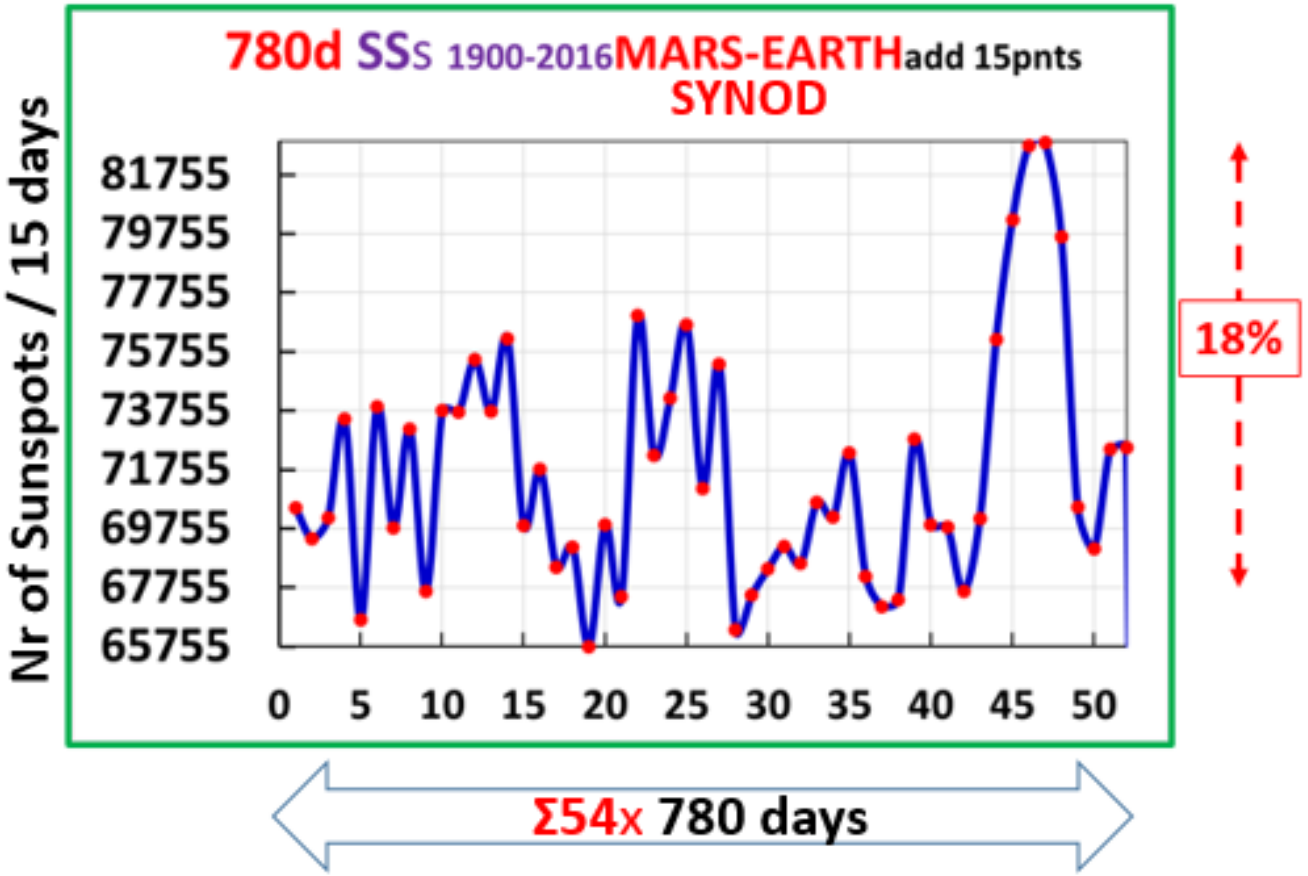
Figure 12. The *left* side shows the LS periodogram for the ten year effective atmospheric temperature data at the location of the LNGS [23]. On the *right* side, the LS periodogram of the effective atmospheric temperature data after the seasonal modulation was subtracted statistically is shown. The red lines indicate the significance level of 99.5%.

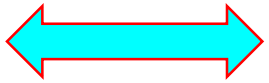
780d



https://arxiv.org/pdf/1808.04207.pdf

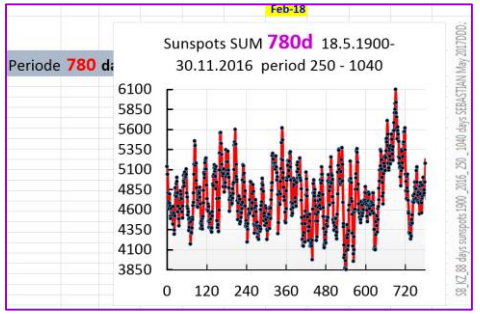
‘*Primitive*’ Fourier analysis



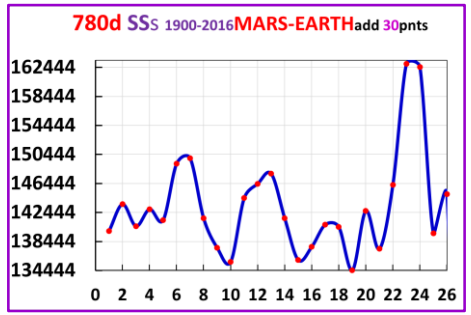


Fourier Analysis

[1 day]



[30 days]



Evidence for a New Component of HE Solar γ-Ray Production

Fermi-LAT
2008-2017

The observed multi-GeV γ-ray emission from the solar disk—sourced by hadronic cosmic rays interacting with gas and affected by complex magnetic fields—is **not understood** ... **Most strikingly**, although six γ rays above 100 GeV were observed during the 1.4 yr of solar minimum, none were observed during the next 7.8 yr. These features, along with a 30–50 GeV dip … were **not anticipated by theory**.

To understand the underlying physics, Fermi-LAT +HAWC obs's of the imminent … solar Minimum are crucial .

Our work:

>>> search for planetary dependence!

PHYSICAL REVIEW LETTERS 121, 131103 (2018)

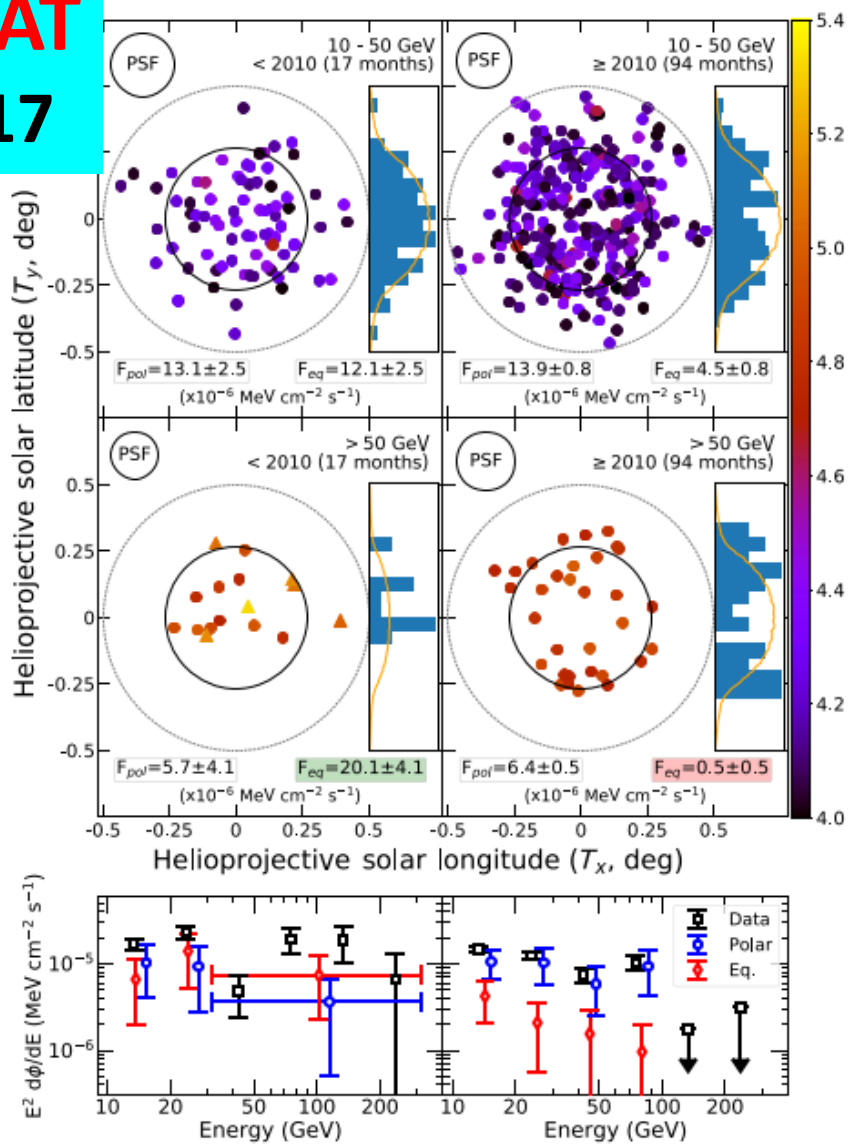


FIG. 2. (Top panel) The location and energy of solar γ rays in helioprojective coordinates. Data are cut into two temporal and two energy bins. The solid disk indicates the solar circle, and the dashed circle indicates the 0.5° ROI. The average 68% containment region of γ rays in each bin is depicted at the top left. The histogram depicts the T_y positions of photons compared to the expectation from isotropic solar emission smeared by the PSF (orange line). Events > 100 GeV are marked with triangles rather than circles. We stress that the exposure after solar minimum significantly exceeds the exposure during solar minimum. Thus, the observed number of counts does not indicate the relative flux. In each bin, we report the flux from the modeled polar and equatorial components, as described in the text. (Bottom panel) The energy spectrum of polar and equatorial emission, divided into regions during (left) and after (right) solar minimum. The polar emission is approximately constant, while the equatorial emission decreases drastically after solar minimum.

T. Linden, B Zhou, JF Beacom, AHG Peter, KCY Ng, Q-W Tang, Phys. Rev. Lett. 121 (25th Sept 2018) 131103
https://doi.org/10.1103/PhysRevLett.121.131103

Conclusions

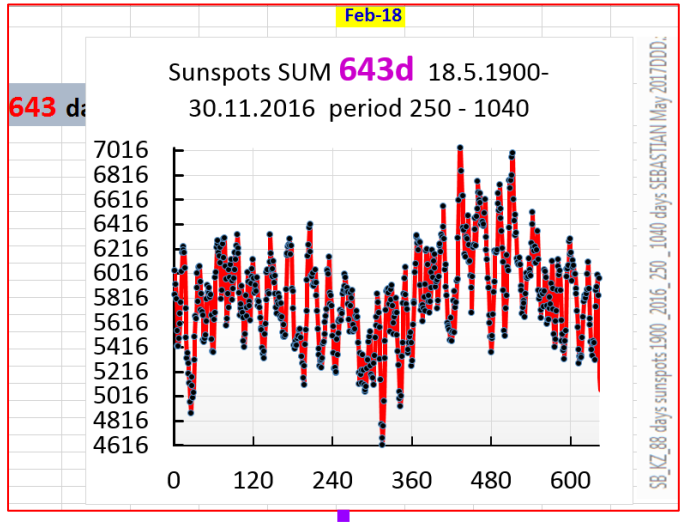
- ✓ Various solar obs's fit planetary gravitational focusing of stream(s) of invisible massive particles ⊗ puzzling solar behaviour:
  Hot Corona, Flares, Elemental composition, MBPs, GMF, **solar radius**, Sunspots, ...
- ✓ Similar obs's with the electron content of the Ionosphere.
- ✓ Nature of the invisible particles not identified yet **=> AQNs? >>** fitting in!
  >> low mass 'WIMPs'?
- ✓ Underground DM exp's, **BOREXINO (TeV μ's?), Fermi LAT mission (~100 GeV γ's?), ...?...**
  => *planetary relationship* **=>** **Any ~11yrs relationship suggestive for re-analysis**
- ✓ DM searches may profit from temporal signal enhancement **>> $10^{11}\times$ >>** screening?
- ✓ Tidal effects on the solar surface are excluded (**$\approx 10^{-12}\cdot SUN_{Gravity}$**) J.Javaraiah, Sol.Phys. 212(**2003**)23
  => the planetary working hypothesis: the only viable scheme >> sofar!
- ✓ More ...

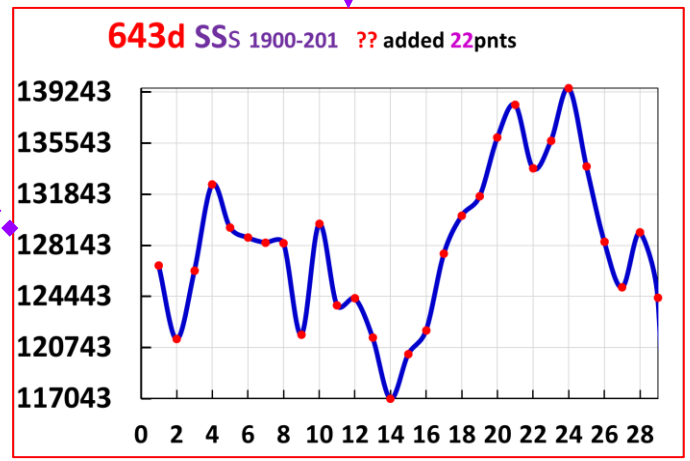
The Dark Universe is not dark!

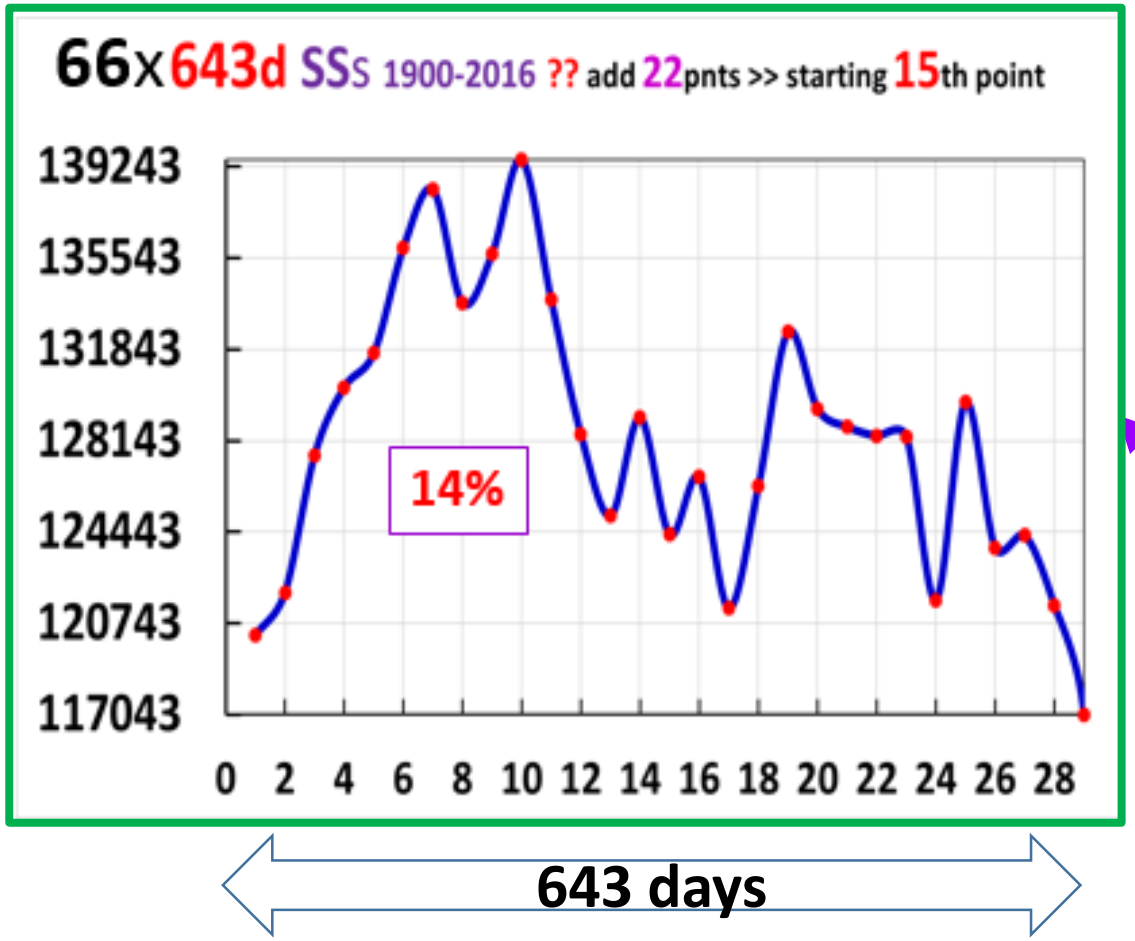
THANK YOU

Additional slides

Original data





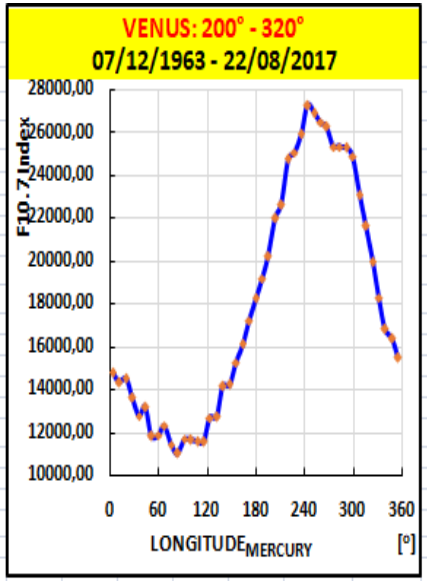


Date [UTC]	
Minimum	Maximum
07/12/1963	22/08/2017

F10.7 [cm]	
Minimum	Maximum
0,0	400,0

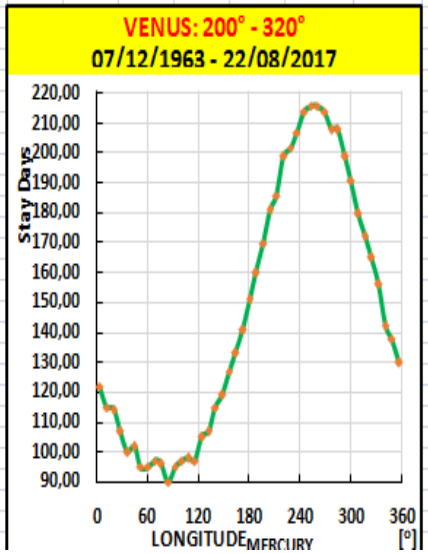
BIN Size [degrees]
8

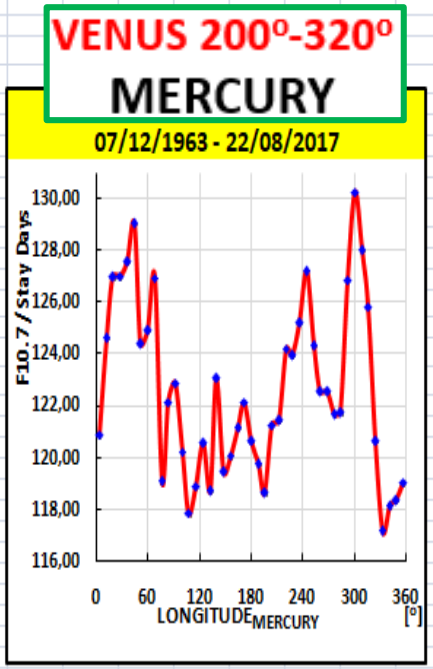
Planet	Planetary Longitude Range [degrees]	
Target	Minimum	Maximum
☉	MERCURY: 0	360
♀	VENUS: 200	320
♁	EARTH: 0	360
♂	MARS: 0	360
♃	JUPITER: 0	360
♄	SATURN: 0	360
☾	LUNA: 0	360



RUN

Integral: Flares Class	Integral: Nr of M-Flares	Class / Nr of M-Flares
807038,2	6572	122,7995





10%

Min <-> Max Value

Cyclic Changes of the Sun's Seismic Radius

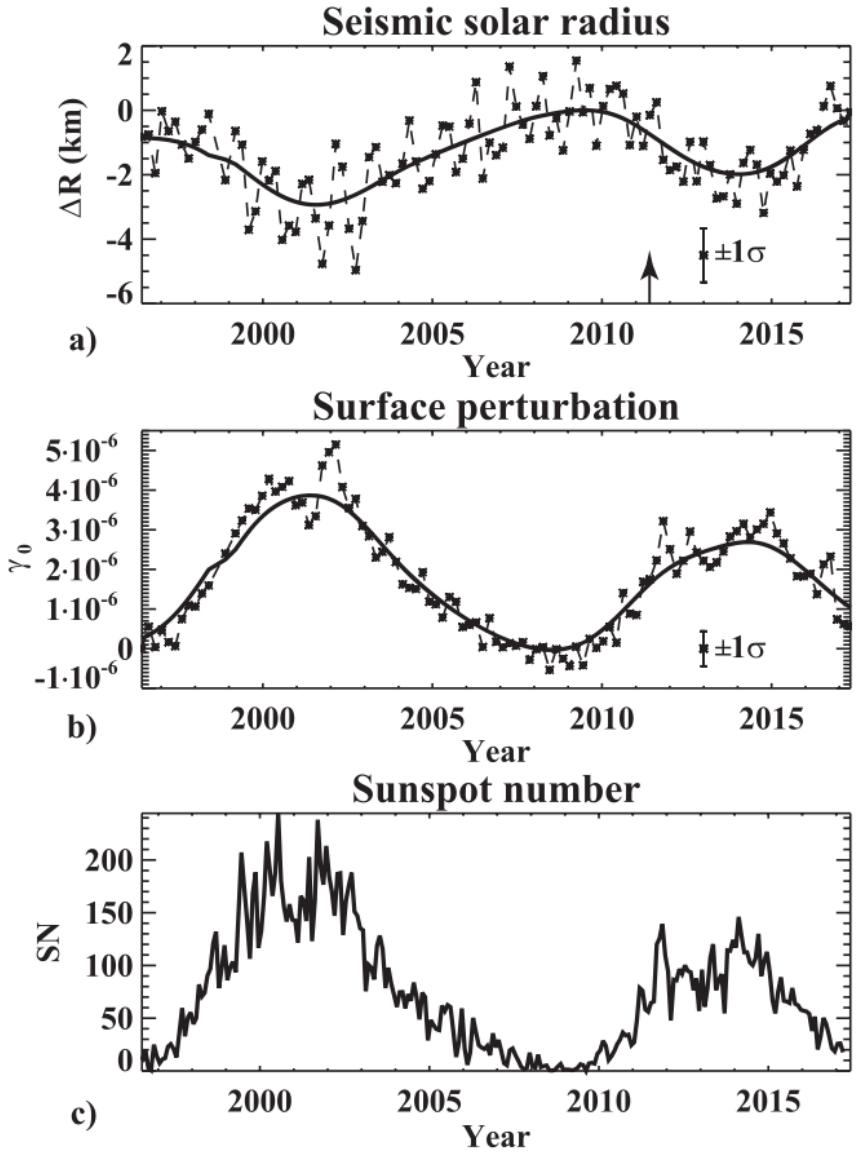
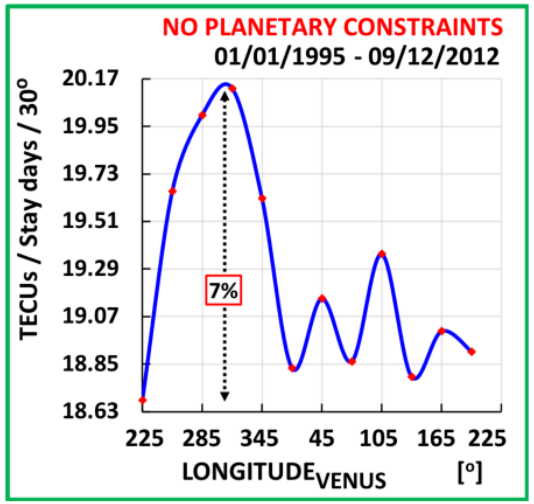


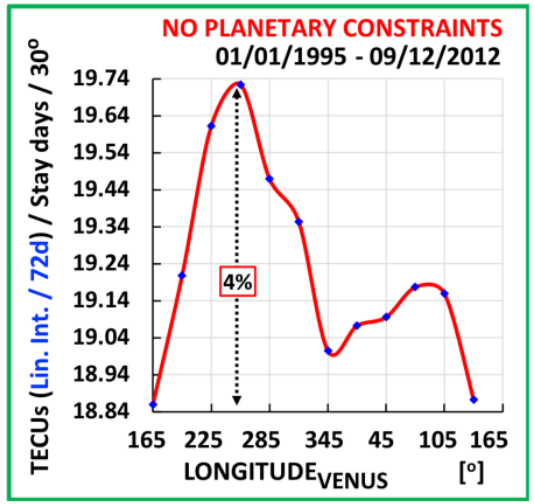
Figure 2. Solar cycle variations of (a) the mean seismic radius, (b) the coefficient, γ_0, of the surface perturbation of *f*-mode frequencies, and (c) the sunspot number averaged for the same time intervals as the helioseismology data. The arrow in panel (a) indicates the start of the HMI data set.

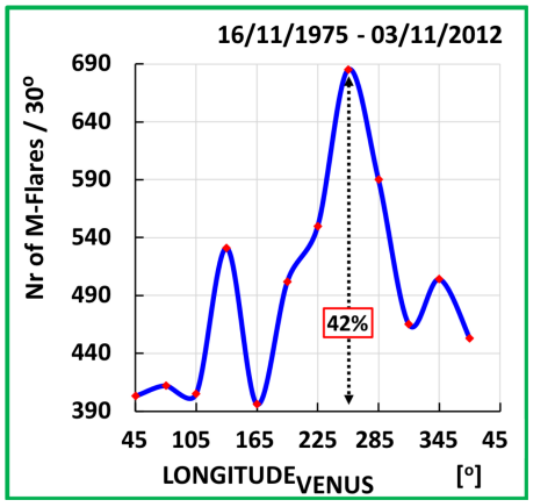
The questions asking whether the Sun shrinks with the solar activity and what causes this have been a subject of debate. **Helioseismology** ***provides a means to measure with high precision the radial displacement of subsurface layers, the so-called "seismic radius"*** through the analysis of oscillation frequencies of surface gravity (f) modes. Here, we present results of a new analysis of **21 years** of helioseismology data from two space missions, the SOHO and the SDO, which allow us to resolve previous uncertainties and compare variations of the seismic radius in two solar cycles. ***After removing the f-mode frequency changes associated with the surface activity***, we find that ***the mean seismic radius is reduced by 1–2 km during the solar maxima and that most significant variations of the solar radius occur beneath the visible surface of the Sun at a depth of about (5 ± 2) Mm, where the radius is reduced by (5–8) km.*** **These variations can be interpreted as changes in the solar subsurface structure caused by the predominately vertical ~10 kG magnetic field.**

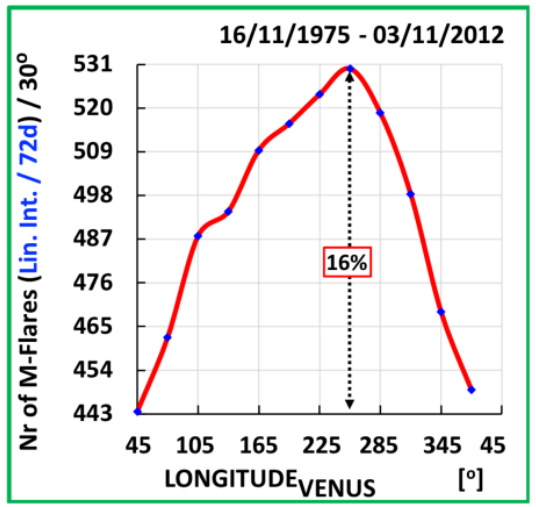
A. Kosovichev, J-P. Rozelot,
ApJ. 861 (**2018**) 90; https://arxiv.org/abs/1805.09385

SIMULATION:

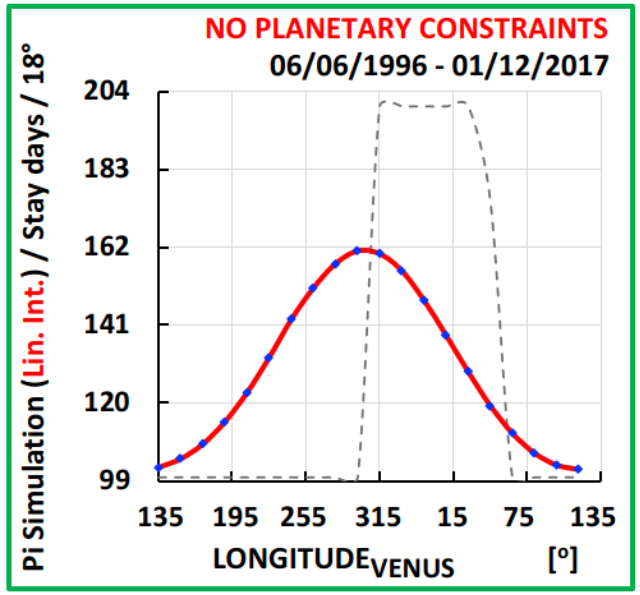


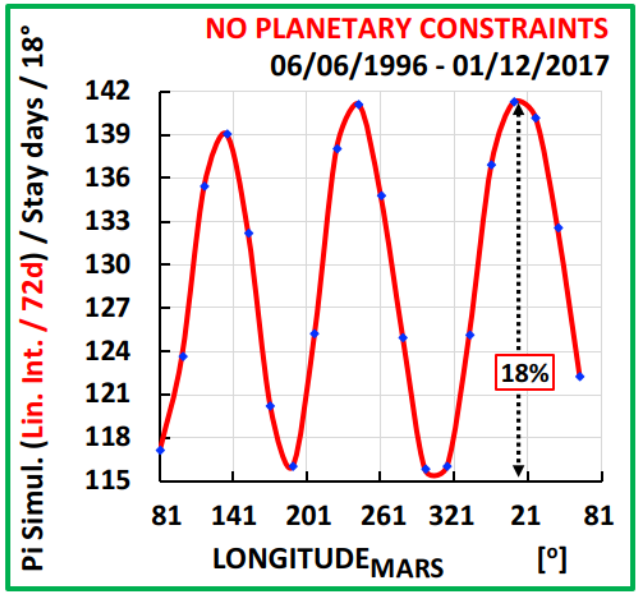






Pi Distribution In VENUS (65 days width)





Solar Flares 1859-

- physical mechanisms/relationship *flare activity* ⇔ *sunspot activity*

  2 of the hottest + biggest problems in solar physics **2013**

  (Hathaway 2010; Hudson 2011); http://www.astron-soc.in/bulletin/13December/237412013-feng.pdf

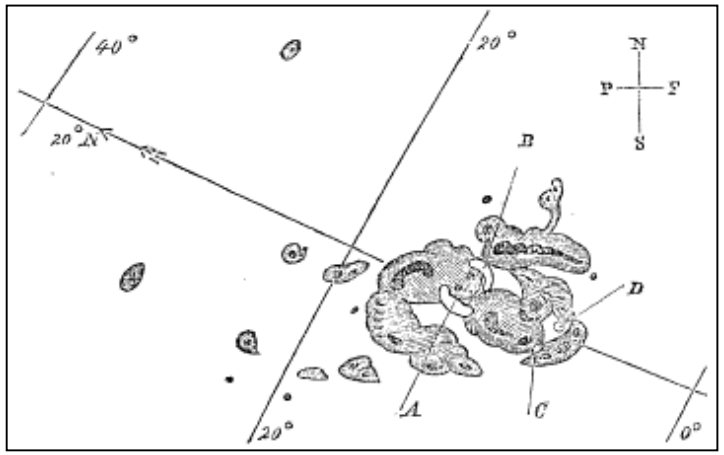
- *… solar flares + CMEs … one of* ***the great solar mysteries*** **2014**

  http://solarscience.msfc.nasa.gov/quests.shtml

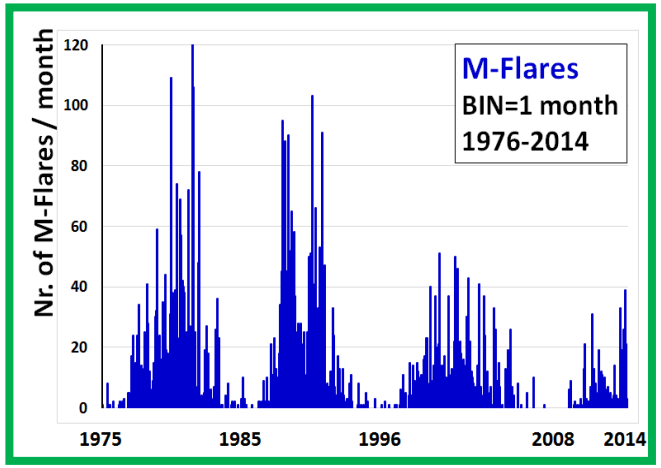
- *what powers a flare? what triggers it?*

  unpredictable for more fundamental reasons? C.J. Schrijver **2009**

The "*first flare*": 1st Sept 1859



R.C. Carrington, MNRAS 20 (**1859**) 13



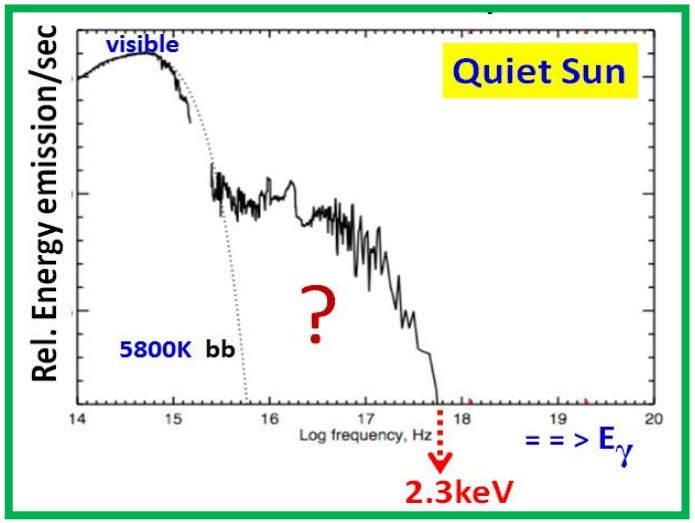
time

Solar Corona 1939- >>> observational mystery.

Sun's upper atmosphere much hotter than its surface => why?

- *" a major open issue in astrophysics"* **2015**
- *"one of the fundamental outstanding problems in solar physics"* **2015**
- ***"for 77 years…one of the outstanding unsolved problems in astrophysics"*** **2015**

[http://arxiv.org/abs/1502.07401 ; http://arxiv.org/abs/1508.05354; DOI: 10.1098/rsta.2014.0269]



*The striking **EUV excess** of the quiet Sun is the manifestation of the **solar corona problem**.*

H.S. Hudson

Zur Frage der Deutung der Linien im Spektrum der Sonnenkorona.

nachdem schließlich die Anzeichen dafür sich mehr und mehr verdichten, daß in den äußeren Zonen der Sonnenatmosphäre Bedingungen für die Anregung von Spektrallinien vorliegen, die weit über das hinausgehen, was bei thermischem Gleichgewicht zu erwarten wäre, scheint es nicht mehr völlig abwegig, die Frage zu diskutieren, ob die Koronalinien als verbotene Linien hochionisierter Atome zu deuten sind.

16. März 1939 W. GROTIAN.

http://dx.doi.org/doi:10.1007/BF01488890

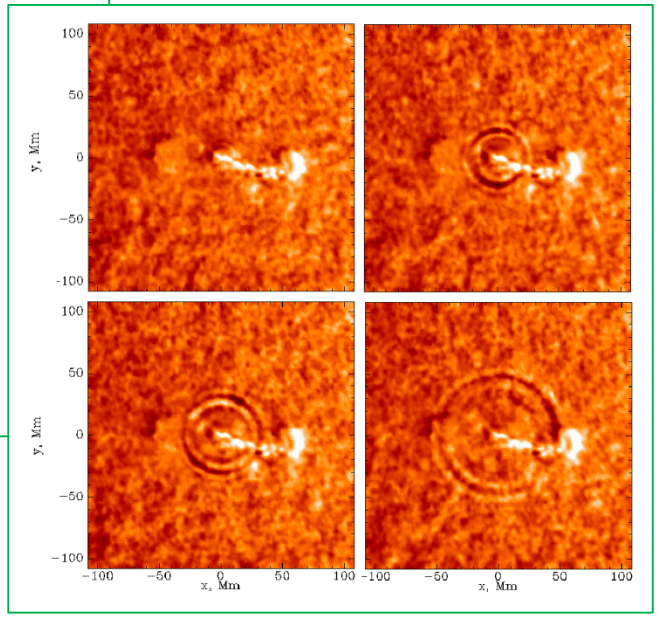
Solar quakes: 1998-

- … *are still* ***mysterious*** arXiv:**1402**.1249v1.
- *"Surprising: in some cases, the sunquak initiating impacts are observed in the early impulsive or even pre-heating phase.. and even without a significant hard X-ray signal"*

  Kosovichev; Sharykin; Zimovets **1/6/2014**
- *"… the energy transported downwards … is somehow invisible … the flux in something propagating downwards through the Sun's atmosphere must be detected"*. **arXiv:1508.07216v1** ApJ. (**2015**).
- *"like ripples spreading from a rock dropped into a pool of water"*

  http://sohowww.nascom.nasa.gov/bestofsoho/Helioseismology/mdi026.html
- **many open questions** … most notably the nature of the excitation mechanism(s) comes from a source area

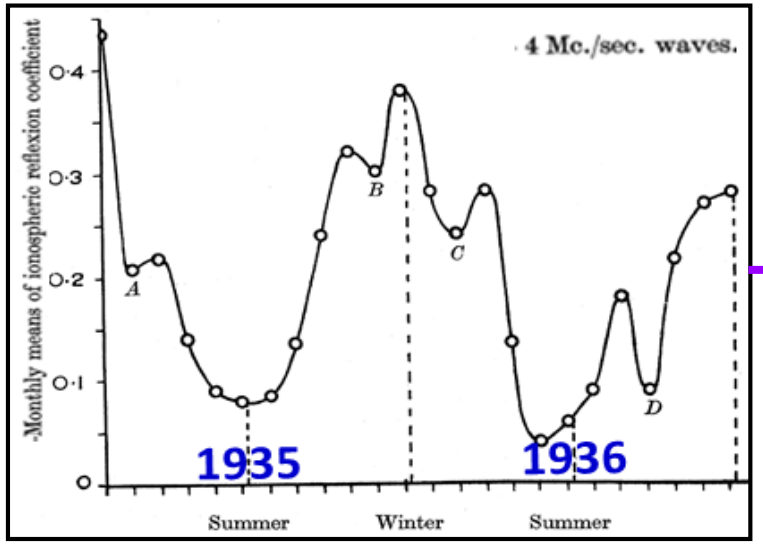
  ~(3000km)^2 ➔ $10^{11\pm1}$ erg/cm^2 arXiv:1602.08245 **2016**



Earth's Atmosphere 1937

- *…peak electron density around December is greater than around June* **=> *unexpected***
  a long-standing unexplained annual anomaly
- **"the writers are inclined to the view that the cause is associated with the Earth or its motion…" 1938**
  doi:10.1029/TE043i001p00015
- .. there is a global **annual anomaly.**

J. Lean *et al.*, J.G.R. 116 (**2011**) A10318, doi:10.1029/2011JA016567

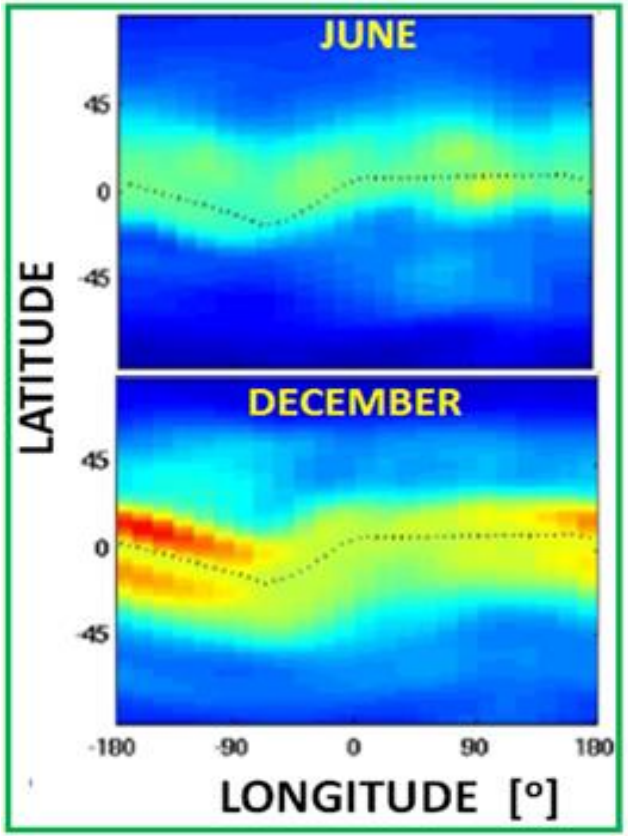


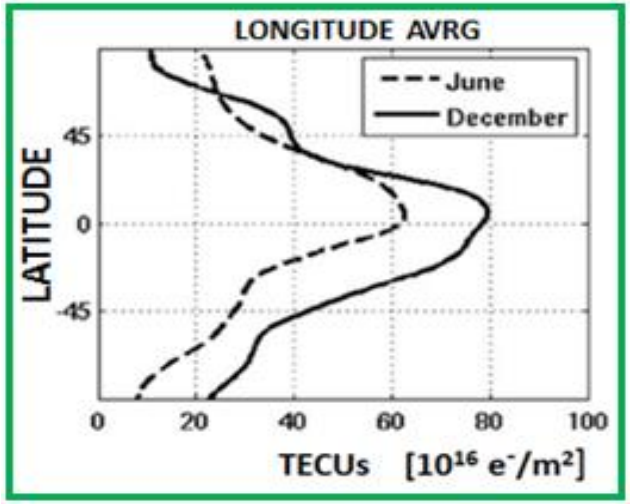
Proc. Roy. Soc. London A162 (**1937**) 451

Total **E**lectron **C**ontent

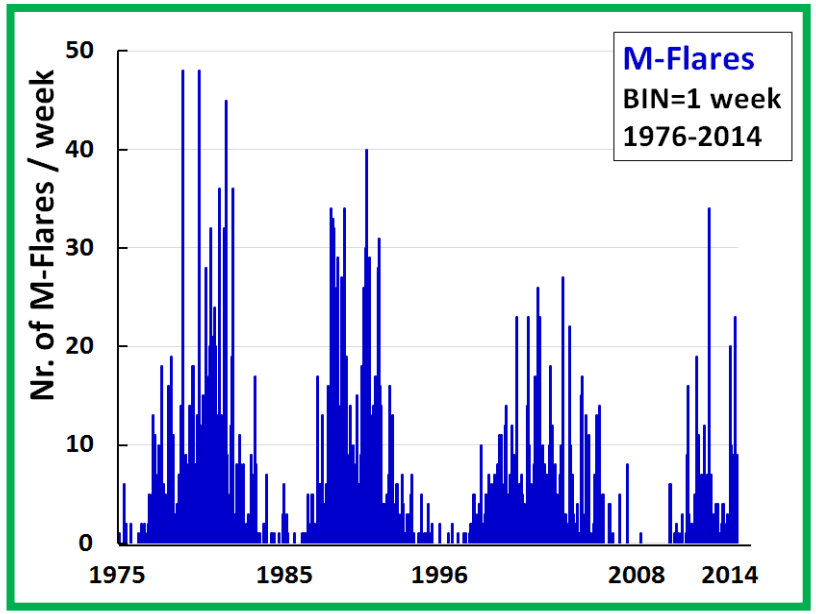
Dec ⇔ June

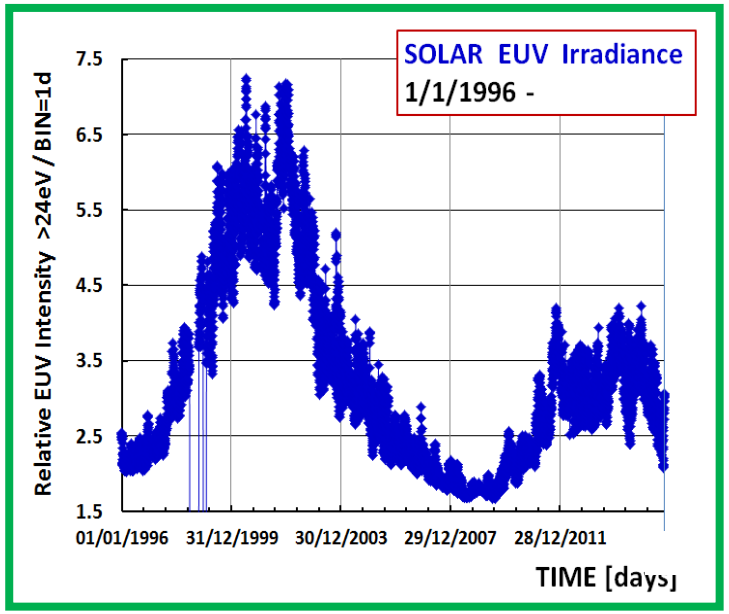
2.87 ⇔ 2.12 [$10^{32}e^-$]

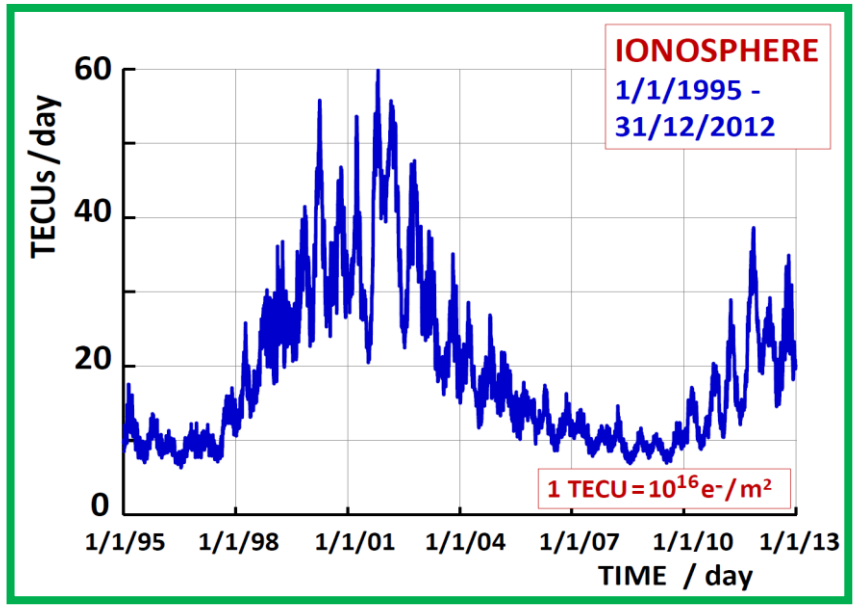


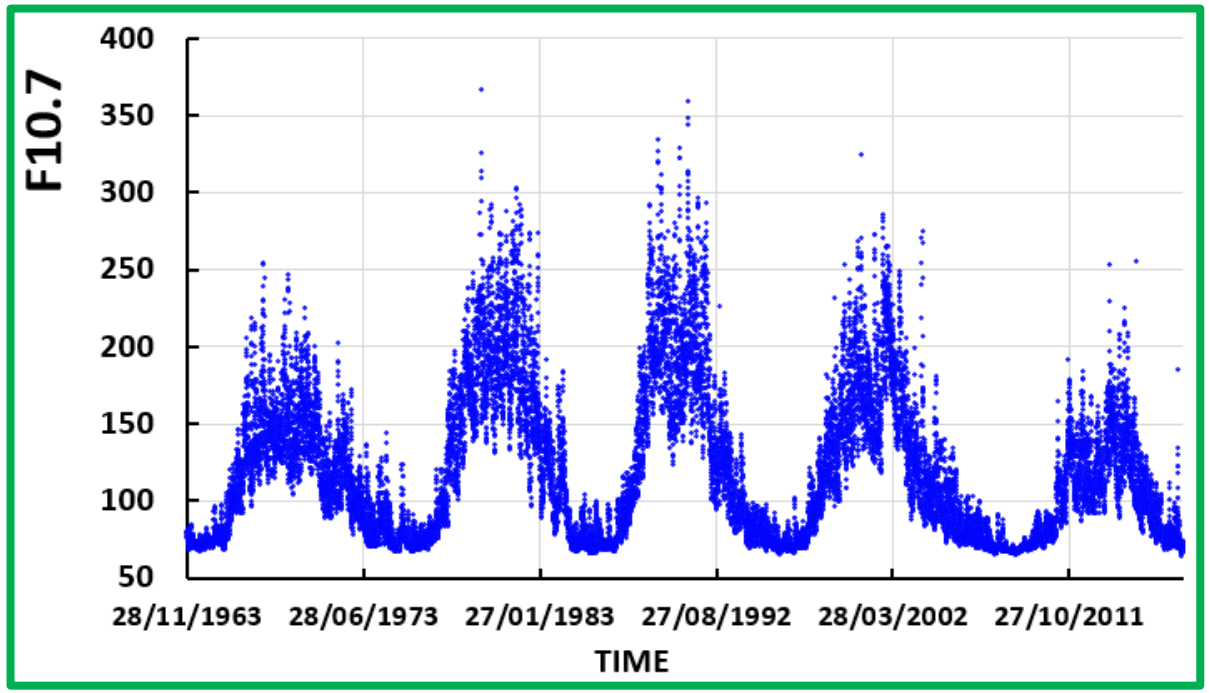


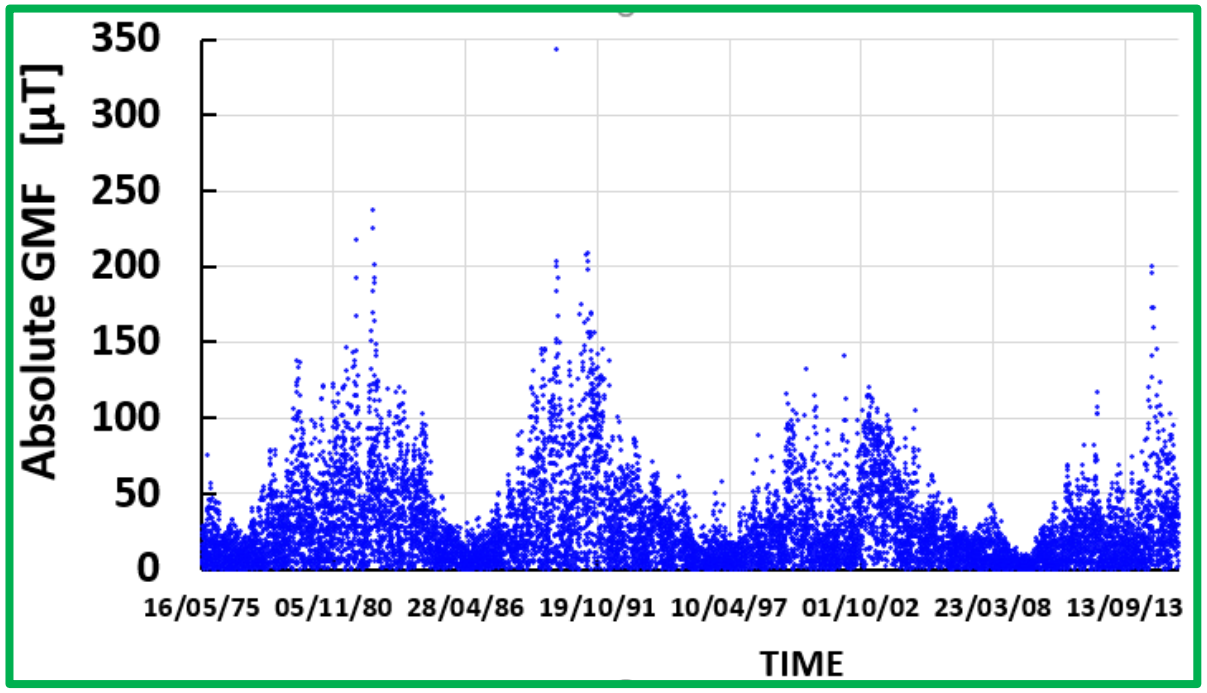
J. Atm. Sol.-Terr. Phys. 67 (**2005**) 1377


M-Flares
BIN=1 week
1976-2014
Nr. of M-Flares / week
0
10
20
30
40
50
1975
1985
1996
2008
2014


SOLAR EUV Irradiance
1/1/1996 -
Relative EUV Intensity >24eV / BIN=1d
1.5
2.5
3.5
4.5
5.5
6.5
7.5
01/01/1996
31/12/1999
30/12/2003
29/12/2007
28/12/2011
TIME [days]


IONOSPHERE
1/1/1995 -
31/12/2012
TECUs / day
0
20
40
60
1 TECU = 10^16 e⁻ / m²
1/1/95
1/1/98
1/1/01
1/1/04
1/1/07
1/1/10
1/1/13
TIME / day


F10.7
50
100
150
200
250
300
350
400
28/11/1963
28/06/1973
27/01/1983
27/08/1992
28/03/2002
27/10/2011
TIME


Absolute GMF [μT]
0
50
100
150
200
250
300
350
16/05/75
05/11/80
28/04/86
19/10/91
10/04/97
01/10/02
23/03/08
13/09/13
TIME