Observation of geo-antineutrino flux from potassium-40 decays and related problems for the physics of the Sun and the Earth.

L.B.Bezrukov and V.V.Sinev

INR, Moscow

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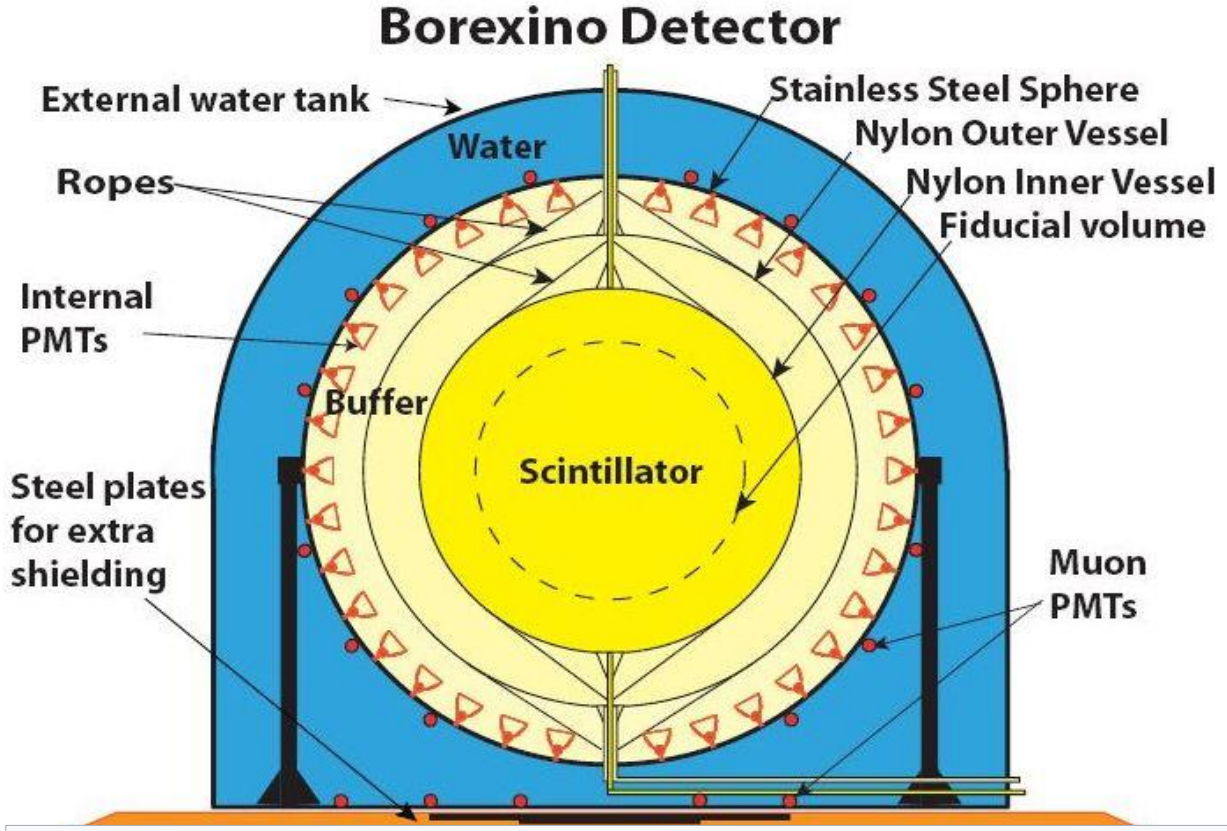

Location	**Laboratori Nazionali del Gran Sasso**
Start of data-taking	**2007**
End of data-taking	**2021**
Detection technique	**Elastic scattering on liquid scintillator(PC+PPO)**
Height	**16.9 m**
Width	**18 m**
Active mass(volume)	**278 tonnes (315 m^3) ≈100 tonnes fiducial**

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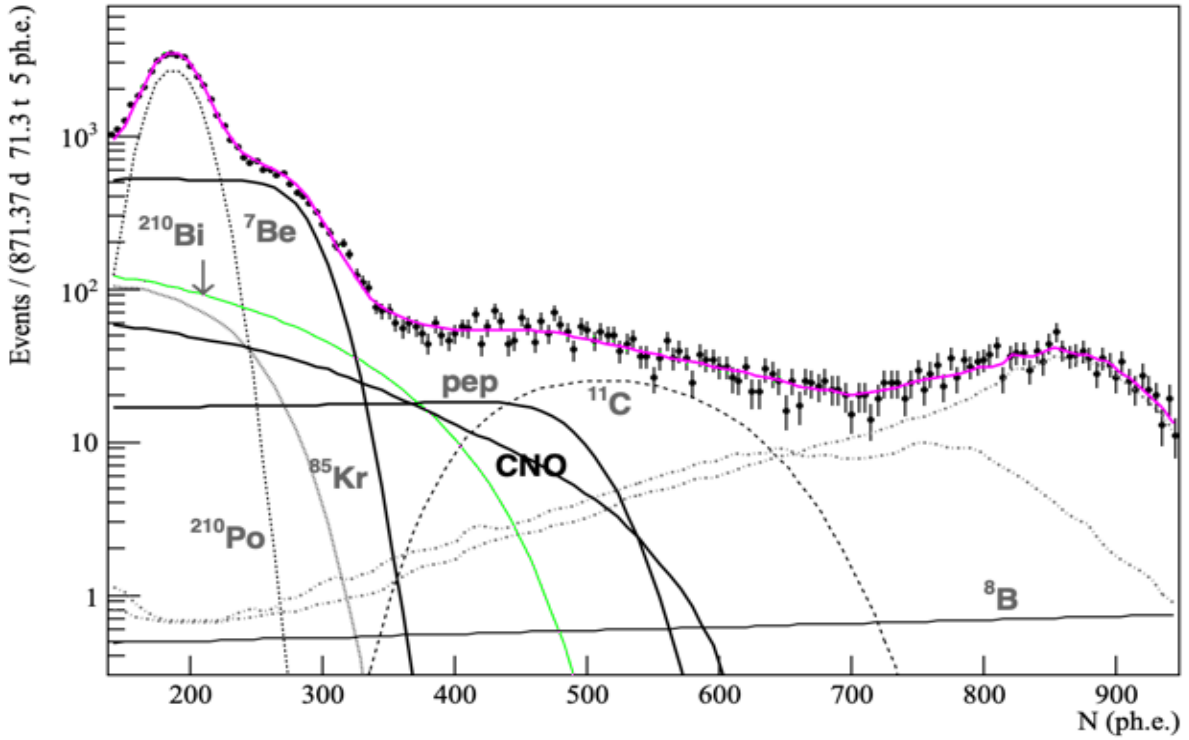


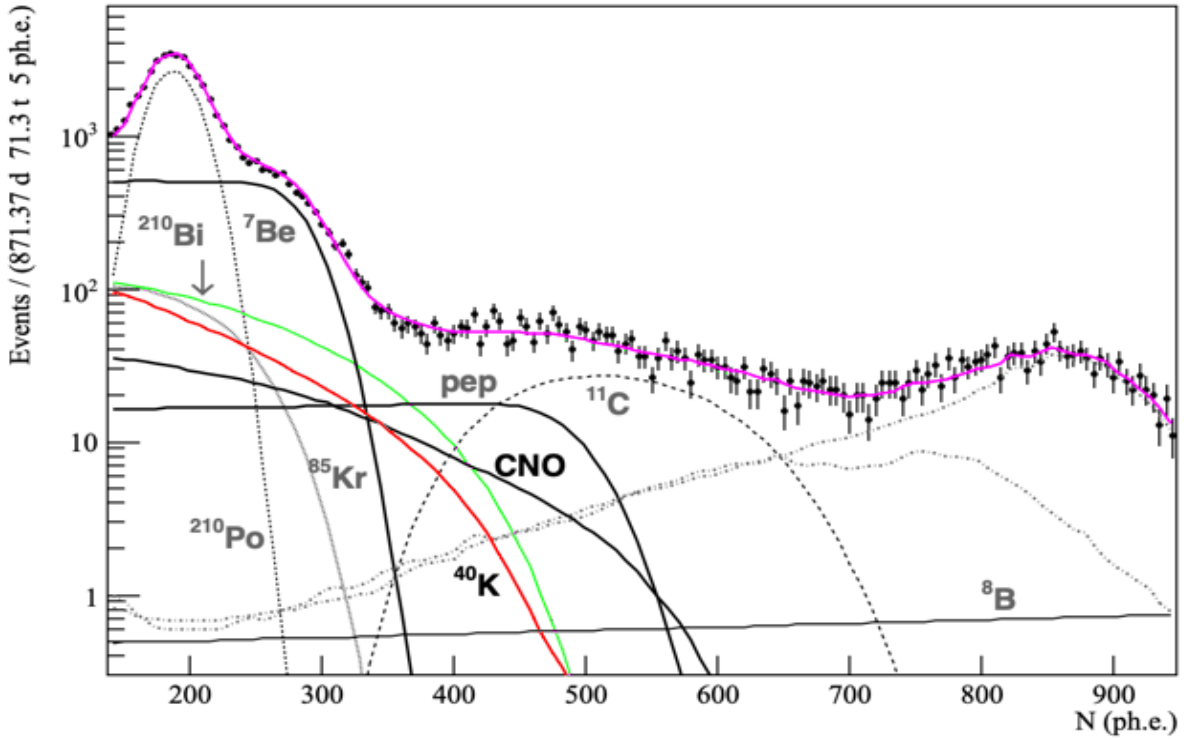
Repeating the analysis of the Borexino collaboration:

χ^2 = 200/162

R_{CNO} = 6.7 – 7.0 cpd/100 t

Fig. The energy spectrum of single events in the Borexino experiment and its components.

Introduction to the analysis of ^{40}K geo-antineutrino events



χ^2 improves and solar neutrino fluxes become consistent with the low-metallicity solar model.

χ^2 = 173/162

R_{CNO} = 3 cpd/100 t
R_{40K} = 11 cpd/100 t

Fig. The energy spectrum of single events in the Borexino experiment and its components + events from 40K geo-anti-neutrinos (red curve).

Sequence of analysis with the introduction of 40K.
Numbers – the counting rate in units count per day in 100 ton: cpd/100t
Our choice – LZ solar model.

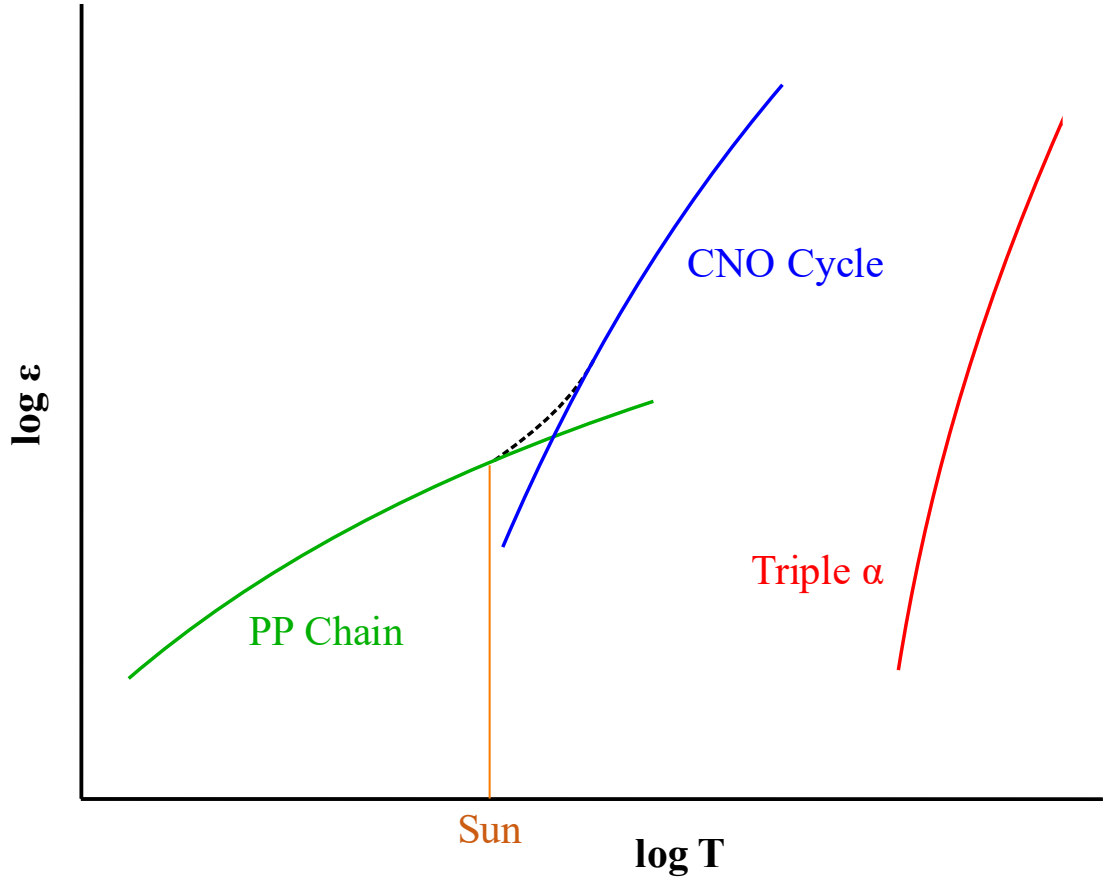
^{7}Be(862)	pep	^{8}B	CNO	^{40}K	χ^2
48.4 ± 1.2	2.74	0.16	7.6 ± 1.2	0	198.405
45.9 ± 1.3	2.74	0.16	4.4 ± 0.6	11	170.834
45.4 ± 1.6	2.8 ± 0.3	0.12 ± 0.05	5.2 ± 1.6	11	169.075
43.6 ± 1.5	2.9 ± 0.3	0.14 ± 0.05	2.6 ± 0.6	19.1 ± 2.5	161.102

LZ 43.7 +- 2.5 3.25+-0.37

HZ 47.9 +- 2.8 4.92+-0.55

Experimental poinps:
162

Logarithm of the relative energy output (ε) of proton–proton (p–p), CNO, and triple-α fusion processes at different temperatures (T). The dashed line shows the combined energy generation of the p–p and CNO processes within a star.



1% of the Earth's Mass of potassium will give 2.18 cpd/100t in Borexino (if K uniformly distributed)

The potassium abundance from our analysis is:

(11- 4) cpd / 2.18 = 3.2%

(19 -5) cpd /2.18 = 6.4%

The Hydridic Earth model (HE-model), introduced by Vladimir Larin, predicts the potassium abundance up to 4% of the Earth's Mass.

Conclusion: the prediction of the HE-model was confirmed.

Our choice

- K → 4%
- H = 600 TW
- Hydridic Earth model

Hydridic Earth (HE) model
(primordially Hydrogen-Rich Planet)

was born 50 years ago in Russia

- Larin's law: $(X_M/X_{Si})_{Earth} = (X_M/X_{Si})_{Sun} \cdot F(E_{IP}(M))$;

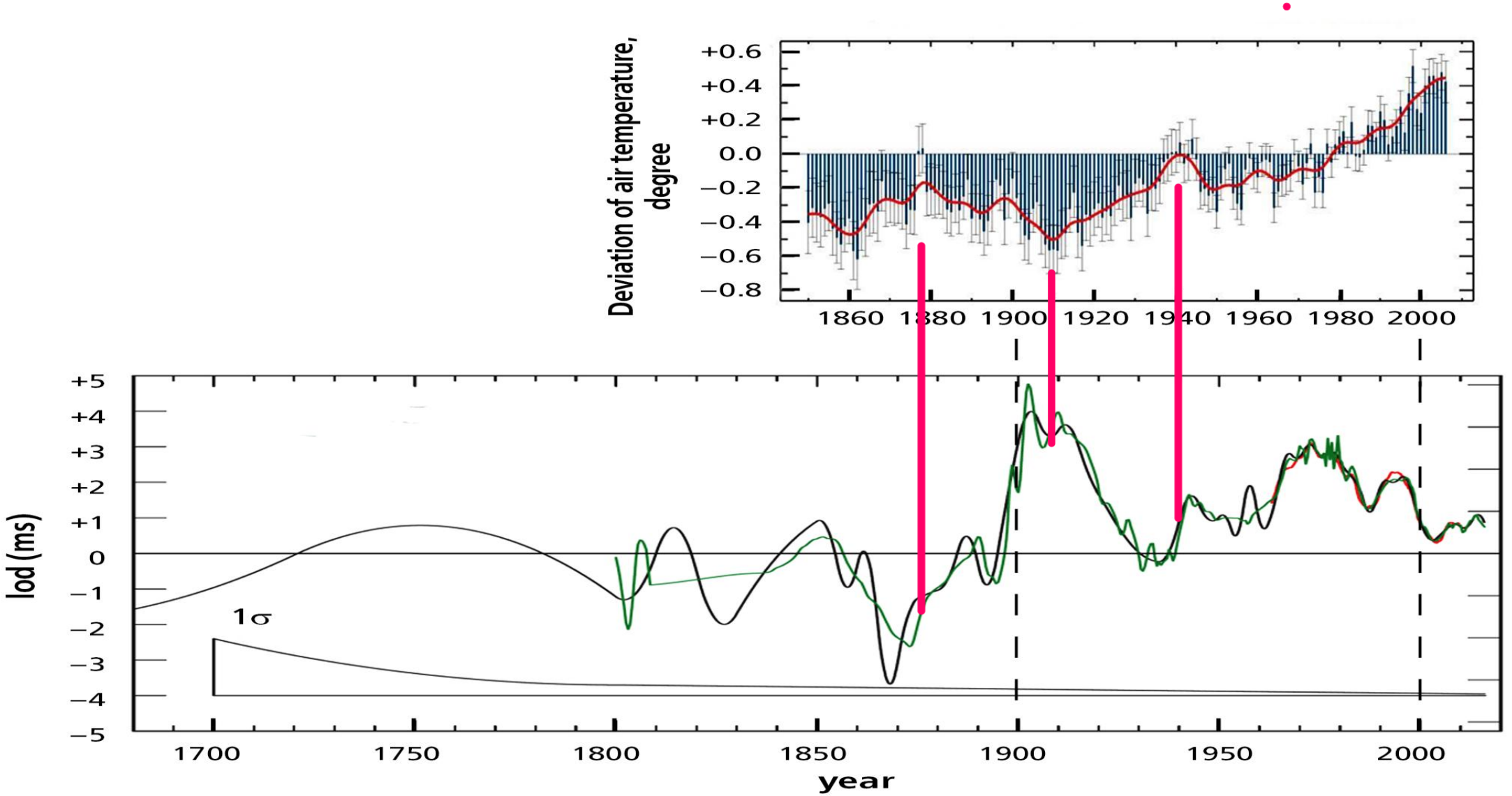
where X_M is the mass fraction in the planet mass of the chemical element with atomic number M, $E_{IP}(M)$ is the ionization potential of the chemical element with atomic number M,

- $F(E_{IP}(M)) = A \cdot \exp\{- B \cdot E_{IP}(M)\}$

Chemical differentiation of planets: a core issue. Herve Toulhoat, Valerie Beaumont, Viacheslav Zgonnik, Nikolay Larin, Vladimir N. Larin. Aug 2012. 15 pp. e-Print: arXiv:1208.2909 [astro-ph.EP]

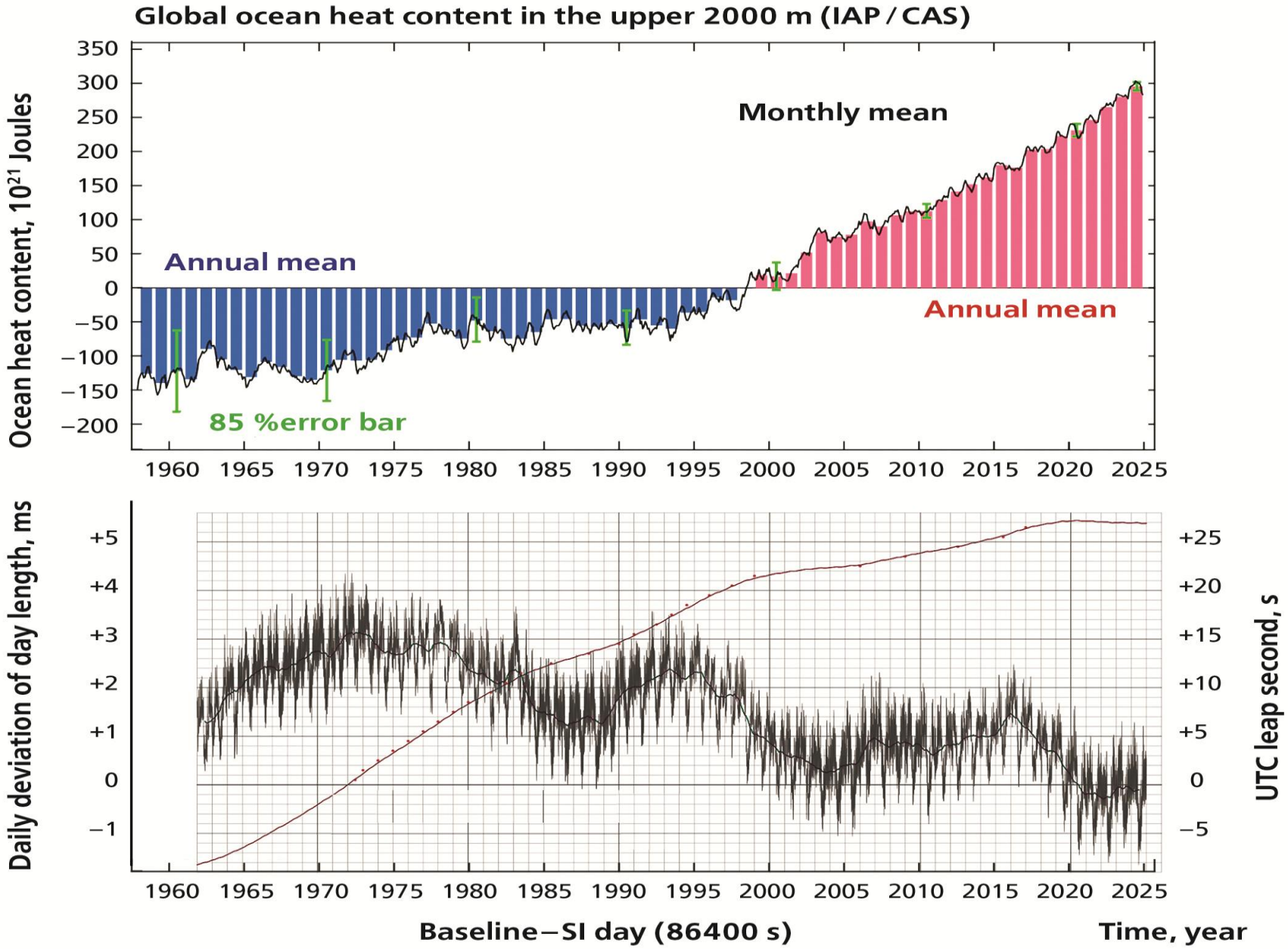
There is an unexpected prediction of the HE-model: climate warming should coincide in time with a decrease in the length of the day (or a decrease in the radius of the Earth).

Let's take a look...



a. Deviation of Earth air temperature versus time. b. Deviation of length of day (lod) from SI-based day (86'400 s). Lod 1700 - 2015 derived from lunar occultations. The red curve starting from 1962 presents open access product of IEPS (Paris Observatory).

Stephenson FR, Morrison LV, Hohenkerk CY. 2016 Measurement of the Earth's rotation: 720 BC to AD 2015. *Proc. R. Soc. A* 472: 20160404. http://dx.doi.org/10.1098/rspa.2016.0404

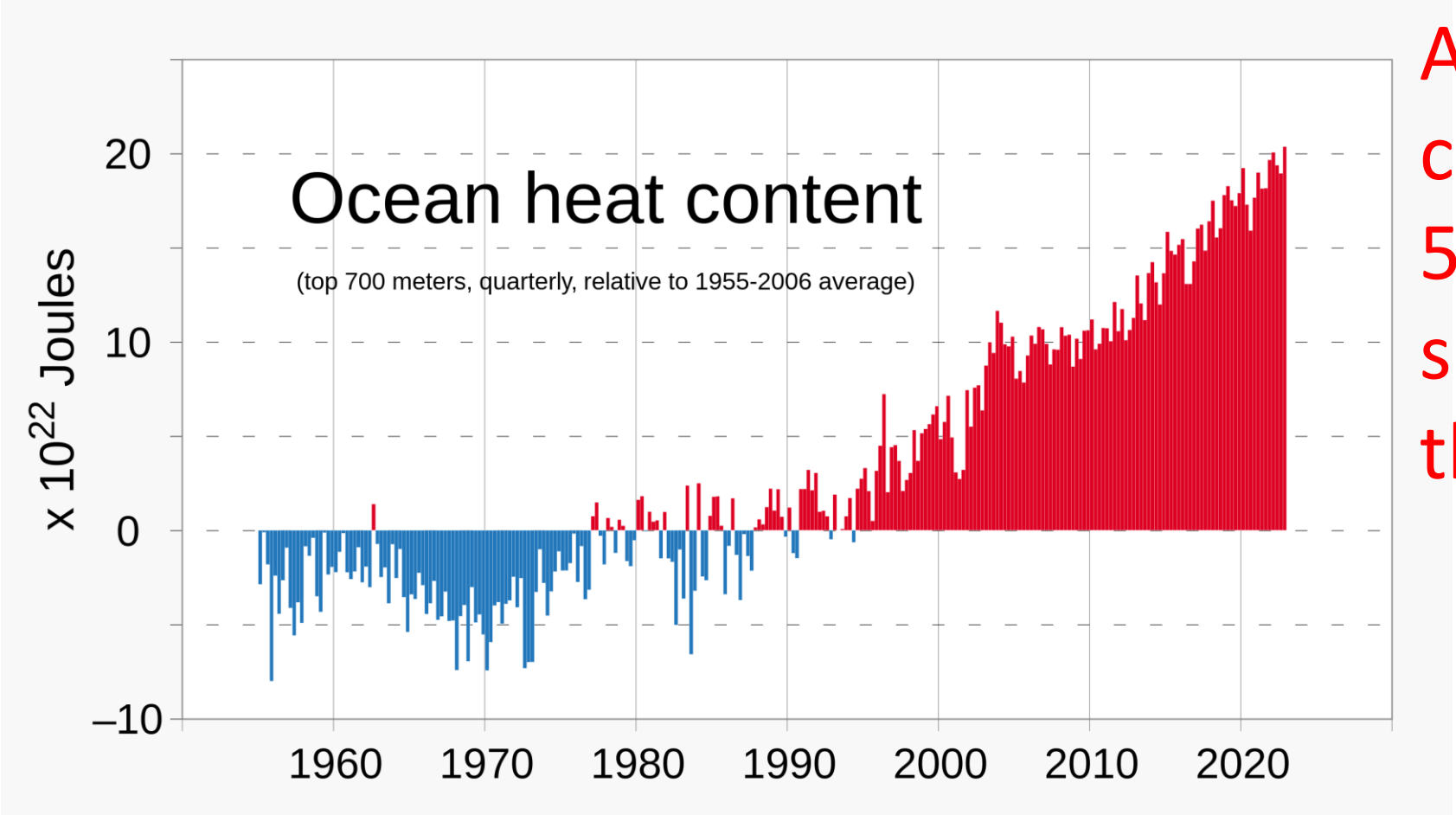


a. Global ocean heat content in upper 2000 m (IAP CAS). b. Deviation of day length from SI-based day. For comparison, the UTC leap seconds is displayed.

https://www.climate.gov/news-features/understanding-climate/climate-change-ocean-heat-content

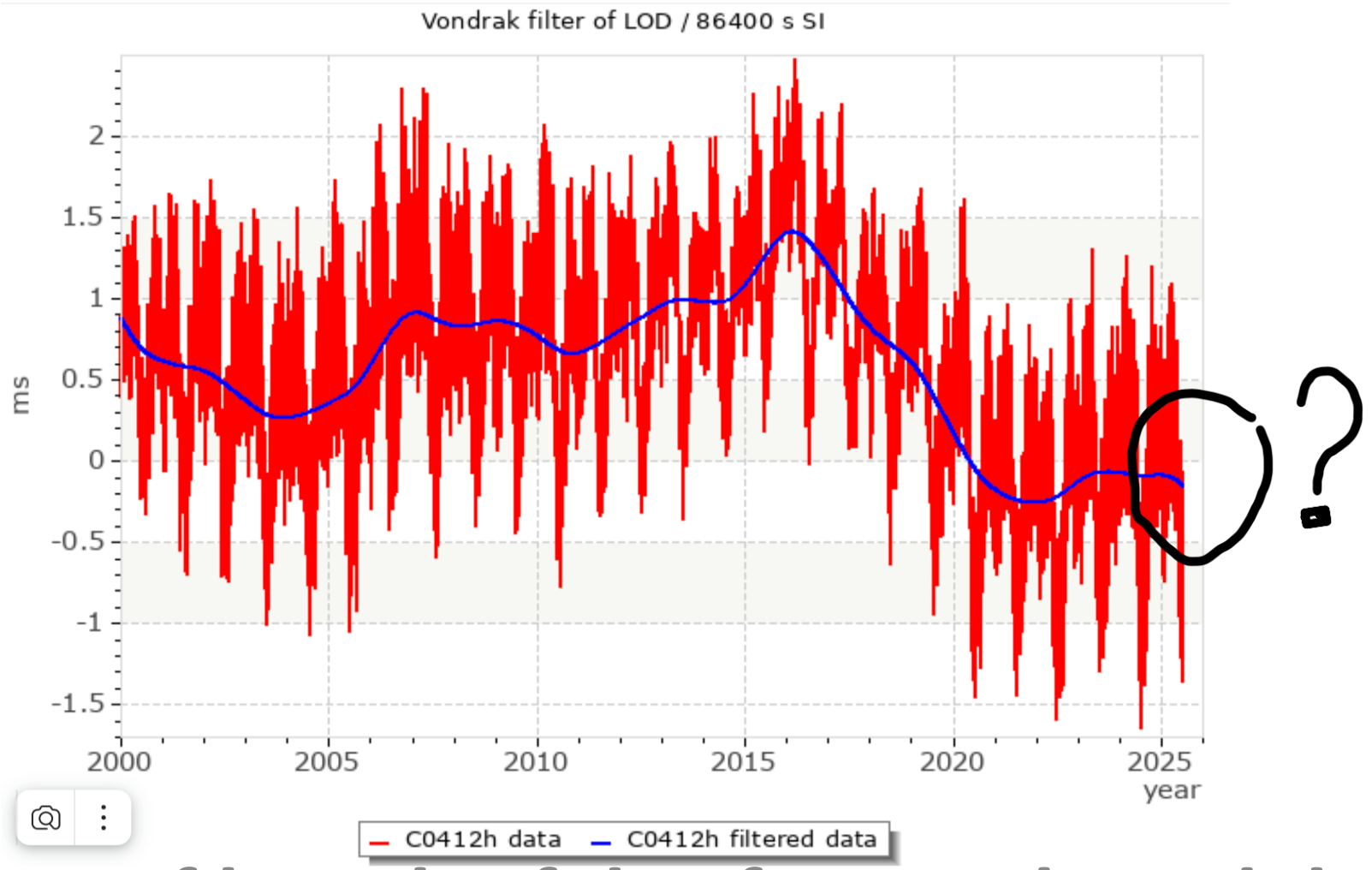
$$H = \rho c_p \int_{h2}^{h1} T(z)dz$$

ρ - water density, Cp- sea water specific heat capacity, h2 - bottom depth, h1 - top depth, T(z)- temperature profile

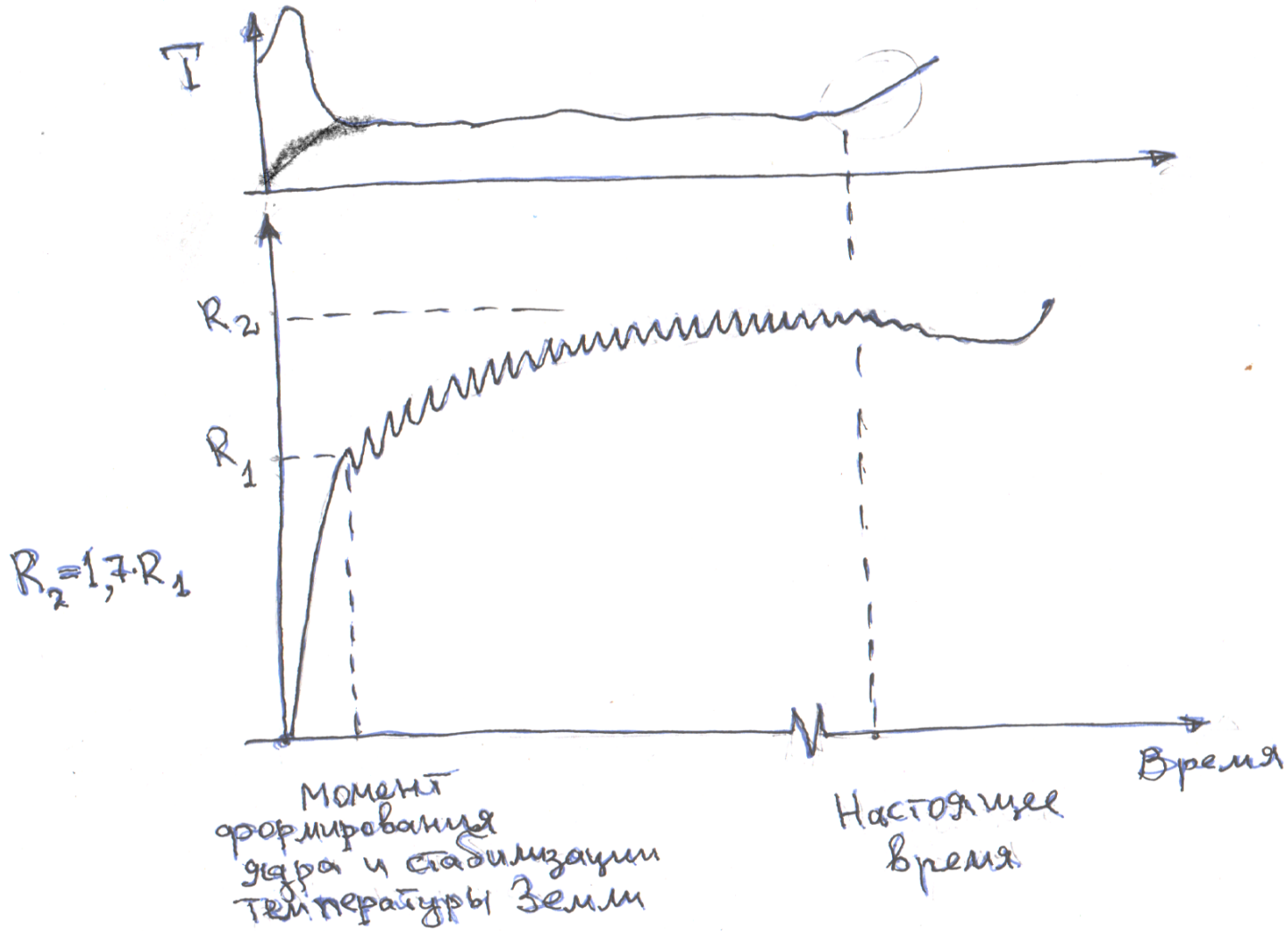


A heater with a capacity of 300 to 500 TW is sufficient to heat the ocean like this.

What is happening now?
https://hpiers.obspm.fr/eop-pc/index.php



Deviation of length of day from SI-based day.



Bependence of the Earth's radius and the temperature of the crust (oceans) on time. Prediction of the Earth model – Hydridic Earth (HE – model)

Conclusion.

- Our analysis has shown that nature is better described by the Hydridic Earth model and the Solar model of low metallicity.
- Experimental data confirm the prediction of the HE-model: climate warming should coincide in time with a decrease in the length of the day (or a decrease in the radius of the Earth).

Связь уменьшения длительности суток с изменением радиуса Земли.

- Пусть dT = -1 ms за 10 лет.
- Из сохранения момента M = mvR имеем:

$dT/T = 2\,dR/R = -1.16\,10^{-8}$

- dR = - 4 cm
- Гравитационная энергия: $U = 3Gm^2/5R = 2\,10^{32}$ J
- $dU = U\,dR/R = -1.2\,10^{23}$ J
- Какая мощность обеспечивает эту работу (нагрев тела Земли) за 10 лет?

Ответ: $3.6\,10^{14}$ W = 360 ТВт + 600 ТВт(40К) = 1000 ТВт

Обнаружение большого количества калия в Земле поддерживает новую модель Земли.

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- L.B. Bezrukov, A.S. Bykovsky, V.V. Sinev. **Low metallicity solar model finds the prove in Borexino data.** ArXiv:2505.13470[hep-ex]. 8 May 2025.

За сколько времени нагреет океан на 0,7 градус нагреватель мощностью 1000 Твт?

- J = W t = C (T1 – T2) m
- t = 4000·0,7·1.4 10^21 /1000 10^12/ 3600/8640 = 120 лет

- Наблюдается нагрев атмосферы на 0,7 градуса за 100 лет.

$$F_{rad} = \varepsilon \cdot \sigma \cdot T^4$$

F_{rad} – radiogenic heat flux,

$\varepsilon = 0{,}90$ – emissivity of atmosphere,

$\sigma = 5{,}67 \cdot 10^{-8}\ W \cdot m^{-2} \cdot K^{-4}$ - Stefan-Boltzmann constant.

- $5{,}67 \cdot 10^{-8} \cdot 255^4 = 239{,}7\ W \cdot m^{-2}$

255 K = - 18 °C (273,16 C – 18)

- $5{,}67 \cdot 10^{-8} \cdot 255{,}15^4 = 240{,}3\ W \cdot m^{-2}$

255,15 K = - 17,85 °C

На стационарной орбите центробежная сила равна притяжению между Землёй $\boldsymbol{M_E}$ и Луной $\boldsymbol{M_L}$ или исскуственным спутником:

$$\frac{\boldsymbol{M_L \cdot v^2}}{\boldsymbol{r}} = \frac{\boldsymbol{G \cdot M_L \cdot M_E}}{\boldsymbol{r^2}}.$$

Пусть масса Земли меняется тогда:

$$\frac{\boldsymbol{dM_E}}{\boldsymbol{M_E}} = -\frac{\boldsymbol{dr}}{\boldsymbol{r}}.$$

Вычислим изменение расстояния до Луны за год, исходя из предсказания Ларина об изменении массы на 20% за жизнь Земли $\boldsymbol{T}$ за счёт потери водорода:

$$\boldsymbol{dr} = -\frac{\boldsymbol{dM_E}}{\boldsymbol{M_E}} \cdot \frac{\boldsymbol{r}}{\boldsymbol{T}} = \boldsymbol{2} \text{ см}.$$

Эту оценку и наблюдаемую величину в 3,8 см можно примерить, учтя то, что потеря водорода не константа во времени. При молодой Земле сила притяжения на поверхности была больше.

Расширение Земли

- 650 ТВт = 325 ТВт + 325 ТВт
- A = W·t = M·g·Δh
- $\Delta h = \frac{3.25 \cdot 10^{14} \cdot 3 \cdot 10^{7} \cdot 4.5 \cdot 10^{9}}{5 \cdot 3 \cdot 10^{24}\text{кг}} = 2.9 \cdot 10^{6}$ м современная мантия 4 10^{24} кг
- Если t = 30 лет, то Δh = 2 см
- R = 6.7 · 10^{6}м
- R_0 = 3.8 · 10^{6}м