New evidence for anomalies of radio-active decay rates

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Abstract

A new piece of evidence for the periodic variations of nuclear decay rates in astrophysical time scales has been reported by Sturrock et al: now in the case of ^{222}Ra nuclei. In this article the TGD inspired explanation for the variations is developed in more detail by utilizing the data provided in this article. The explanation relies on nuclear string model predicting the existence of almost degenerate ground states of nuclei (in the natural MeV energy scale) with excitations energies assumed to lie in keV energy range. The variations of the decay rates defined naturally as averages for the decay rates of excitations would be induced by keV radiation from the solar corona. The would also explain the anomalously high temperature of solar corona and relate the observed periodicities to the rotation rate of corona.

1 Introduction

Lubos Motl told about new evidence for periodic variations of nuclear decay rates reported by Sturrock et al in their article *Analysis of Gamma Radiation from a Radon Source: Indications of a Solar Influence* [C2]. The abstract of the article summarizes the results.

This article presents an analysis of about 29,000 measurements of gamma radiation associated with the decay of radon in a sealed container at the Geological Survey of Israel (GSI) Laboratory in Jerusalem between 28 January 2007 and 10 May 2010. These measurements exhibit strong variations in time of year and time of day, which may be due in part to environmental influences. However, time-series analysis reveals a number of periodicities, including two at approximately 11.2 year^{-1} and 12.5 year^{-1}. We have previously found these oscillations in nuclear-decay data acquired at the Brookhaven National Laboratory (BNL) and at the Physikalisch-Technische Bundesanstalt (PTB), and we have suggested that these oscillations are attributable to some form of solar radiation that has its origin in the deep solar interior. A curious property of the GSI data is that the annual oscillation is much stronger in daytime data than in nighttime data, but the opposite is true for all other oscillations. This may be a systematic effect but, if it is not, this property should help narrow the theoretical options for the mechanism responsible for decay-rate variability.

The following gives a brief quantitative summary of the findings. Radioactive decays of nuclei have been analyzed in three earlier studies and also in the recent study.

1. BNL data are about ^{36}Cl and ^{32}Si nuclei. Strong day-time variation in month time scale was observed. Twofrequency bands ranging from 11.0 to 11.2 year^{-1} and from 12.6 to 12.9 year^{-1} were observed.

2. PTB data are about ^{226}Ra nuclei. Also now strong day-time variation was observed with frequency bands ranging from 11.0 to 11.3 year^{-1} and from 12.3 to 12.5 year^{-1} .

3. GIS data are about ^{222}Ra nuclei. Instead of strong day-time variation a strong night-time variation was observed. Annual oscillation was centered on mid-day. 2 year^{-1} is the next strongest feature. Also a night time feature with a peak at 17 hours was observed. There are also features at 12.5 year^{-1} and 11.2 year^{-1} and 11.9 year^{-1}. All these three data sets lead to oscillations in frequency bands ranging from 11.0 to 11.4 year^{-1} and from 12.1 to 12.9 year^{-1}.

4. Bellotti et al studied ^{137}Cl nuclei deep underground in Gran Sasso. No variations were detected.

2 Could exotic nuclear states explain the findings?

The TGD based new physics involved with the effect could relate to the excitations of exotic nuclear states induced by em radiation arriving from Sun. This would change the portions of various excited nuclei with nearly the same ground state energy and affect the average radio-active decay rates.

1. The exotic nuclei emerge in the model of nucleus as a nuclear string with nucleons connected by color flux tubes having quark and antiquark at ends [K1]. The excitations could be also involved with cold fusion. For the normal nuclei color flux tubes would be neutral but one can consider also excitations for which quark pair carries a net change $\pm e$. This would give rise to a large number of nuclei with same em charge and mass number but having actually abnormal proton and neutron numbers. If the energy differences for these excitations are in keV range they might represent a fine structure of nuclear levels not detected earlier.

   Could these exchanges take place also between different nuclei? For instance, could it be that in the collision of deuterium nuclei the second nucleus can be neutralized by the exchange of scaled down W boson leading to neutralization of second deuterium nucleus so that Coulomb wall could disappear and make possible cold nuclear reaction. It seems that the range of this scaled variant of weak interaction is quite too short. M_{127} variant of weak interactions with W boson mass very near to electron mass could make possible this mechanism.

2. The exchange of weak bosons could be responsible for generating these excitations: in this case two neutral color bonds would become charged with opposite charges. If one takes seriously the indications for 38 MeV new particle [C1], one can even consider a scaled variant of weak interaction physics with weak interaction length scale given by a length scale near hadronic length scale [K4]. E(38) could be scaled down Z boson with mass of about 38 MeV.

Em radiation from Sun inducing transitions of ordinary nuclei to their exotic counterparts could be responsible for the variation of the radio-active decay rates. If course, exotic nuclei in the above sense are only one option and the following argument below applies quite generally.

2.1 Kinetic model for the evolution for the number of excited nuclei

A simple model for the evolution of the number of excited nuclei is as follows:

$$\begin{aligned} \frac{dN}{dt} &= kJ - k_1N \quad \text{for} \quad t \in [t_0, t_1] \quad , \\ \frac{dN}{dt} &= -k_1N \quad \text{for} \quad t \in [t_1, t_0 + T] \quad . \end{aligned} \tag{2.1}$$

J denotes the flux of incoming radiation and N the number of excited nuclei. t_0 corresponds to the time of sunrise and t_1 to the time of sunset and T is 24 hours in the approximation that sun rises at the same time every morning. The time evolution of $N(t)$ is given by

$$\begin{aligned} N(t) &= \frac{k}{k_1}J + (N(t_0) - \frac{k}{k_1}J)exp\left[-k_1(t - t_0\right] \quad \text{for} \quad t \in [t_0, t_1] \quad , \\ N(t) &= N(t_1)exp\left[-k_1(t - t_1)\right] \quad \text{for} \quad t \in [t_1, t_0 + T] \quad . \end{aligned} \tag{2.2}$$

2.2 Explanation for the basic features of the data

The model can explain the qualitative features of the data rather naturally.

1. The period of 1 year obviously correlates with the distance from Sun. .5 year period correlates with the fact that the distance from Sun is minimal twice during a year. Day-time night-time difference can be explained with the fact that em radiation at night-time does not penetrate Earth. This explains also why Gran Sasso in deep underground observes nothing.

2. The large long time scale variation for the day-time data for BNL and PTB seems to be in apparent constrast with that for the night-dime data at GIS. It is however possible to understand the difference.

   (a) If the rate parameter k_1 is large, one can understand why variations are strong at day-time in BNL and BTB. For large value of k_1 $N(t)$ increases rapidly to its asymptotic value $N_{max} = kJ/k_1$ and stays in it during day so that day-time variations due to solar distance are large. At night-time $N(t)$ rapidly decreases to zero so that night-time variation due to the variation of the solar distance is small.

   (b) For GIS the strong variation is associated with the night-dime data. This can be understood in terms of small value of k_1 which can be indeed smaller for ^{226}Ra than for the nuclei used in the other studies. During daytime $N(t)$ slowly increases to its maximum at $N(t_1)$ and decreases slowly during night-time. Since $N(t_1)$ depends on the time of the year, the night-time variation is large.

   (c) The variations in time scales of roughly the time scale of month should be due to the variations in the intensity of the incoming radiation. The explanation suggested in [C2] is that the dynamics of solar core has these periodicities manifested also as the periodicities of the emission of radiation at the frequencies involved. These photons would naturally correspond to the photons emitted in the transitions between excited states of nuclei in the solar core or possibly in solar corona having temperature of about 300 eV. One could in fact think that the mysterious heating of solar corona [E1] to a temperature of 3 million K could be due to the exotic excitations of the nuclei by radiation coming from Sun. At this temperature the maximum of black body distribution with respect to frequency corresponds to energy of .85 keV consistent with the proposal that the energy scale for excitations is keV.

   (d) The difference of frequencies 12.49 year^{-1} and 11.39 year^{-1} is in good approximation 1 year^{-1}, which suggests modulation of the average frequencies with a period of year being due to the rotation of Earth around Sun. The average frequency is 11.89 year^{-1} that is 1/month. The explanation proposed in the article is in terms of rotation velocity of the inner core which would be smaller but same order of magnitude as that of outer core (frequency range from 13.7 to 14.7 year^{-1}). It is however not plausible that the keV photons could propagate from the iinner core of Sun unless they are dark in TGD sense. In TGD framework it would be natural to assign the frequency band to solor Corona.

2.3 Can one assign the observed frequency band to the rotation of solar corona?

The rotation frequency band assignable to photosphere is too high by about $\Delta f = 3$ year^{-1} as compared to that appearing in decay rate variation. Could one understand this discrepancy?

1. One must distinguish between the synodic rotation frequency f_S measured in the rest system of Sun and the rotation frequency observed in Earth rotating with frequency $f = 1$ year^{-1} around Sun: these frequencies relate by $f_E = f_S - f$ giving frequency range 12.7 to 13.7 year^{-1}. This is still too high by about $\Delta f = 2$ year^{-1}.

2. Could corona rotate slower than photosphere? The measurements by Mehta [E2] give the value range 22 - 26.5 days meaning that the the coronal synodic frequency f_C would be in the range 14.0-16.6 year^{-1}. The range of frequences observed at Earth would be 13-15.6 year^{-1} and too high by about $\Delta = 2$ year^{-1}.

If I have understood correctly, the coronal rotational velocity is determined by using solar spots as markers and therefore refers to the magnetic field rather than the gas in the corona. Could the rotation frequency of the gas in corona be about $\Delta f = 2$ year^{-1} lower than that for the magnetic spots?

One can develop a theoretical argument in order to understand the rotational periods of photosphere and corona and why they could differ by about $\Delta f = 2$ year^{-1}.

1. Suppose that one can distinguish between the rotation frequencies of magnetic fields (magnetic body in many-sheeted space-time) and gas. Suppose that photosphere (briefly 'P') and corona (briefly 'C') can be treated in the first approximation as rigid spherical shells having thus moment of inertia $I = (2/3)mR^2$ around the rotational axis. The angular momentum per unit mass is $dL/dm = (2/3)R^2\omega$. Suppose that the value of dL/dm is same for the photosphere and Corona. If the rotation velocity magnetic fields determined from magnetic spots is same as the rotation velocity of gas in corona, this implies $f_C/f_P = (R_S/R_C)^2$, where R_S is solar radius identifiable as the radius of photosphere. The scaling of 13 year^{-1} down to 11 year^{-1} would require $R_C/R_S \simeq 1.09$. This radius should correspond to the hottest part of the corona at temperature about 1-2 million K.

   The inner solar corona extends up to $(4/3)R_S$. This would give average radius of the inner coronal shell about $1.15R_S$. The constancy of $dL/dm(R)$ would give a differential rotation with frequency varying as $1/R^2$. If the frequency band reflects the presence of differential rotation, one has $R_{max}/R_{min} \simeq (f_{max}/f_{min})^{1/2} \simeq (15/13)^{1/2} \simeq 1.07$.

2. One can understand why angular momentum density per mass is constant if one accepts a generalization of the Bohr quantization of planetary orbits originally proposed by Nottale and based on the notion of gravitational Planck constant $\hbar_{gr}$ [K3, K2]. One has $\hbar_{gr} = GMm/v_0$ and is assigned with the flux sheets mediating gravitational interaction between Sun and the planet or some other astrophysical object near Sun. The dependence on solar mass and planetary mass is is fixed by Equivalence Principle. v_0 has dimensions of velocity and therefore naturally satisfies $v_0 < c$. For the three inner planets one has $v_0/c \simeq 2^{-11}$. Angular momentum quantization gives $mR^2\omega = n\hbar_{gr}$ giving $R^2\omega = nGM/v_0$ so that the angular momentum per mass is integer valued. For the inner planets n has values 3,4,5.

3. One could argue that for the photosphere and corona regarded as rigid bodies a similar quantization holds true but with the same vale of n since the radii are so near to each other. Also v_0 should be larger. Consider first photosphere. One can apply the angular momentum quantization condition to photosphere approximate as a spherical shell and rigid body. $I\omega_P = nGmM/v_{0P}$ for $n = 1$ gives $(2/3)R^2\omega = GM/v_{0P}$. For $v_{0P} = c$ one would obtain $\omega_P/\omega_E = (3/2)(R_E/R)^2(v_0/v_{0P}$. For $R_P = .0046491R_E$ (solar radius) this gives $\omega_P/\omega_E \simeq 12.466$ for the $v_0/c = 4.6 \times 10^{-4}$ used by Nottale [K3]: I have often used the approximate nominal value $v_0/c = 2^{-11}$ but now it this approximation is too rough. Taking into account the frequency shift due to Earth's orbital motion one obtains $\omega_P/\omega_E \simeq 11.466$ which is consistent with the lower bound of the observed frequency band and would correspond to R_{max}. The value $v_{0P} = v_{0C} = c$ looks unrealistic if interpreted as a physical velocity of some kind the increase of R_C allows however to reduce the value of v_{0C} so that it seems possible to understand the situation quantitatively.

   If one wants to generalize this argument to differential rotation, one must decompose the system spherical shells or more general elements rotating at different velocities and having different value of $\hbar_{gr}$ assignable to the flux tubes connecting them to Sun and mediating gravitational interaction. This decomposition must be physical.

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