COMPARATIVE RESOLUTIONS OF POSSIBLE TIME VARIATIONS IN THE WEAK INTERACTION COUPLING CONSTANT FROM GEOCHRONOLOGY, OKLO AND PRIMORDIAL NUCLEOSYNTHESIS

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The sensitivity of the geochronological method to time variations in the weak interaction coupling constant is superior to the limits inferred from both the standard model of primordial nucleosynthesis and the observed neutron capture resonance depletion of ^{149}Sm during the criticality of the Oklo natural reactor at ~ 1.8 AE. Shlyakhter's analysis of the Oklo data (1) provides an extreme limitation (1 part in 10^9) on any variation of the strong interaction coupling constant over the past 1.8 AE, but a much less stringent approximate bound on the weak interaction coupling constant, not necessarily better than a few percent.

The flexibility of the standard model of primordial nucleosynthesis to allow for the discovery of new neutrino species without producing conflict with observational constraints has been stressed by Ellis et al., 1986 (2). Identical arguments are applicable to the determination of appropriate model dependent bounds on weak interaction coupling constant variation. Similarly, the flexibility of the standard model to allow for the ~ 4% experimental uncertainty in the neutron half life is equivalent to a ~ 4% allowable variation in *any* ß-decay rates over the period from t ~ 100 sec to the present (i.e., a 2% variation limit on the Fermi coupling constant G_F, corresponding to a linearized limit on $|\dot{G}_F/G_F| = 1.3 \cdot 10^{-12} yr^{-1}$ for $\Delta t = 15$ AE since primordial nucleosynthesis).

Extreme limitations on weak coupling constant variations approximately equal to the Oklo limits on the strong coupling constant exist for Kaluza-Klein and superstring theoretical models possessing *symmetrical* expansions or contractions of the internal scale factors of the 'extra dimensions' in the compactified manifold (3). However, these constraints vanish for models with asymmetrically evolving internal manifolds.

Geochronological methods are potentially capable of resolving variations $\geq 0.3\%$ in the time-integrated ^{87}Rb (ß) decay constant measurable as a difference between present day laboratory values and time-integrated determinations made from high precision Rb-Sr: U-Pb age comparisons of selected pristine terrestrial, lunar and meteorite samples of various ages spanning the maximum available interval of 4.5 AE. This corresponds to a resolution of $4 \cdot 10^{-13} yr^{-1}$ for variation of the SU(2) low energy gauge coupling constant ($|\dot{g}_w/g_w|$), and $8 \cdot 10^{-13} yr^{-1}$ for variation of the Fermi coupling constant ($|\dot{G}_F/G_F|$). These may be compared to the most precise experimental limits on the secular variation of the gravitational coupling constant from the Viking lander ranging data: $|\dot{G}/G| < 8 \cdot 10^{-12} yr^{-1}$ (4), and the inferred limits from primordial nucleosynthesis: $\sim < 1 \cdot 10^{-11} yr^{-1}$ (5) and planetary surface observations: $\sim < 8 \cdot 10^{-12} yr^{1}$(6). Further investigation of the gravitational and weak interaction coupling constants at higher precision resolutions is clearly interesting from the point of view of grand unified theory (7).

Penrose has argued that the (weak interaction mediated) time symmetry breaking decay of the K^o–meson may be a tiny window into an underlying time-asymmetric physics (8). Geochronological monitoring of weak interaction behaviour over very long periods of time may provide another larger window into time-asymmetric effects relating directly to the cosmological 'arrow of time'.

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