It is the author's suspicion that God modified some single fundamental aspect of the natural order which in turn affected all the fundamental forces—including the gravitational force, the electrostatic force, and the nuclear forces—in a manner that did not fatally disrupt the delicate balances that exist in living systems and whose signature in the astronomical data may be subtle. The author believes that the sooner the community of scientists who are aware of the integrity of the Bible is convinced the system of natural law that normally describes the orderly behavior of the cosmos cannot have been time-invariant, the sooner genuine progress will be made in establishing the framework that accounts for Noah's Flood and the geological history of our planet in a robust and satisfying way.

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MINISYMPOSIUM ON VARIABLE CONSTANTS—X

RADIOHALO EVIDENCE REGARDING CHANGE IN NATURAL PROCESS RATES

R. H. BROWN*

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Abstract

Radio halos provide a direct comparison of the results of identical physical processes that occurred over a period encompassing a large fraction of Earth's history. Accordingly they can demonstrate changes in natural process rates, i.e., in basic physical law, that occur too slowly to be demonstrated by observations made during the epoch of modern science, or that occurred episodically before the development of modern investigative capability.

The identifiability of radiohalo rings with the alpha-particle sources that produced them, together with the sharpness of these rings indicate that radioisotope half-lives over a range of 21 orders of magnitude have not varied by more than a factor of two during the time the geological formations of the Earth which contain radio halos have been in existence, and probably over the entire time represented by geological formations. A plausible further deduction from this evidence is that there has been no significant variation in the nuclear long-range force, the nuclear short-range force, or the electrical interaction force during this time interval.

Introduction

Since the beginning of modern scientific insights there has been intense curiosity over whether the basic physical processes (interactions) of the natural world are universal in both space and time, or have been characterized by evolutionary change. Biblical creationists are particularly interested in this topic because of difficulties that have developed with respect to some chronological conclusions which have been drawn from specifications in the Bible.

The basic physical interactions of the natural world appear to be so complexly interacting and so finely balanced as to exclude large change in the associated "laws." Such evidence supports the theist viewpoint that the Creator has optimally designed and optimally maintains the physical universe. Speculation concerning either constancy or variability of fundamental natural process rates, i.e., basic physical laws, over the history of the physical universe calls for data which clearly favors one possibility against the other.

Within the short time span of modern scientific measurements there has been no firm indication of change in basic physical relationships (laws). Within the constraints of soundly interpreted experimental data, one must conclude that whatever changes in basic physical processes (laws) may have occurred, either take place too slowly to be apparent over the time span of modern observational capability, or have occurred episodically before the era of modern science.

Radiohalos provide a direct physical means for comparison of results of identical processes which have operated over most of the history of the present geologic features of Earth's crust. Consequently they may be expected to provide straightforward evidence concerning the constancy of basic relationships (laws) in the natural world.

*R. H. Brown, Ph. D., Geoscience Research Institute, Loma Linda University, Loma Linda, CA 92350.

^{238}U Radiohalo Characteristics

Microphotograph of ^{238}U radiohalo sets have been published by Robert Gentry (1974, 1987). The natural formation of a ^{238}U radiohalo ring set requires a minute concentration of mineral foreign to the lattice in which the rings are formed. The radioactive (radium-like) transition of ^{238}U in this foreign mineral to stable ^{206}Pb releases a series of eight alpha particles which disrupt the crystal lattice structure in the surrounding area to form the concentric spherical damage patterns which are exhibited as rings in cross-section. Figure 1 gives an idealized scale model in half cross-section.

Although the alpha particles associated with a set of radiohalo rings are produced in sequence, as indicated in Table I, the rings develop simultaneously. After the radioisotope decay has reached equilibrium in which each stage has the same number of disintegrations per unit time as every other stage, all rings (shells) develop at the same rate. (This feature does not apply to isolated polonium radiohalo sets which may begin with a relatively short half-lived parent and proceed to a longer-lived daughter.)

The density of each ring is inversely proportional to the square of its radius (shell surface area). Consequently, in a reproduction of a photograph the inner rings may be indistinguishable due to overexposure, or the outer ring may be indiscernible due to underexposure. Rings (shells) are produced because the capability of an alpha particle for producing crystal lattice dislocation increases as the alpha particle is slowed, producing a sharp maximum damage at the end of its path. The density of radiohalos is a nonlinear function of the number of alpha particles per unit area, and does not provide a useful means for estimating exposure e. For a more detailed discussion see Michael R. Owen, 1988. Dr. Owen's paper is *essential* reading for anyone who wishes to understand radiohalos.

Another factor complicating the interpretation of uranium radiohalo ring density is the demonstrated independence of polonium radiohalo ring sets and complete uranium radiohalo ring sets, commonly associated with each other (Gentry, 1987). Since Po can be separated from U in natural processes and independently deposited at foreign mineral centers in a crystal lattice, both Po and U could be deposited at the same center, the Po either simultaneously or subsequently, resulting in the three Po rings being darker than they would be if only U had been deposited. I am not aware of any investigation of relative ring densities for the purpose of determining Po/U ratios in centers for U halo sets, but valuable information would be obtained from such investigation.

The half-life associated with each radiohalo is determined by the short-range and long-range attractive forces within the atomic nucleus, and by the Coulomb (electrical) repulsive force between protons in the nucleus. Large changes in half-life may be expected from relatively small changes in these nucleon interaction forces (Siemens and Jensen, 1987, chapters 2 and 10; Preston and Bhaduri, 1975, chapters 2, 5 and 11).

The penetration range of alpha particles can be measured with high precision in air. Since the stopping power of a medium for alpha particles is determined by Coulomb (electrical) interactions, the higher electron and proton density in a solid with respect to air produces a greatl$_y$ reduced alpha particle range (halo radius). A theoretical calculation predicts alpha particle ranges in mica which are within ± 4% of those observed (Owen, 1988). The range values given in Table I were obtained in this way, using 0.94 ± 0.02 for the conversion from range in quartz to range in biotite (Owen, 1988, Table I). Direct measurement of radiohalo radii in biotite yields values within 0.3% to 4% of the theoretical values given here in Table I, Due to variations in the chemical composition of biotite, and to varying alpha particle energy loss within the varied sizes of foreign mineral centers from which the alpha particles originate, such close agreement is remarkable.

Table I. Uranium-238 radiohalo set data. Sequence number one is first for the emission series, and largest for the radiohalo set sequence. Range values were derived from range-in-air measurements, as explained in the text.

Emission Sequence	Radiohalo Set Sequence	Parent Atom	Half-Life	Daughter Alpha Energy (Mev)	Range in Biotite (microns)
1	8	^{238}U	4.51×10^9 yr	4.20	12.9
2	6	^{234}U	2.48×10^5 yr	4.77	15.6
3	7	^{230}Th	7.52×10^4 yr	4.68	15.1
4	5	^{226}Ra	1600 yr	4.78	16.0
5	3	^{222}Rn	3.823 d	5.48	19.7
6	2	^{218}Po	3.05 min	6.00	22.6
7	1	^{214}Po	1.64×10^{-4} s	7.68	33.6
8	4	^{210}Po	138 d	5.30	18.7
---	---	^{206}Pb	(stable)	----	----

Radioisotope Half-Life Variation Limits

A linear regression for the value of half-life (T) in years and range (R) in microns from Table I yields

$$\ln R = 2.940 - 0.01911 \ln T \tag{1}$$

with a 0.987 coefficient of determination. (A 1.000 coefficient of determination would specify a perfect fit of the data to a linear relationship.) Taking implicit differentiation and rearranging terms we obtain

$$(dT/T) = -52.3\ (dR/R) \tag{2}$$

These equations are valid over the 21 orders of magnitude range of T from 5.20×10^{-12} year for ^{214}Po to 4.51×10^9 years for ^{238}U.

Radiohalo radii are identifiable and may be determined within ± 4% (Owen, 1988, Table I, column 6; see also discussion of column 4). An error analysis of T with respect to R, using equation (2), reveals a maximum half-life variation of ± 2 for a ± 4% variation in range. From these results we may conclude that over the 21 orders of magnitude covered by the data for the radioactive half-lives of uranium and its daughter products, nuclear half-lives have not varied more than a factor of two over the time the geological formations which contain radiohalos have been in existence, and probably over the time represented by all geological formations on planet Earth.

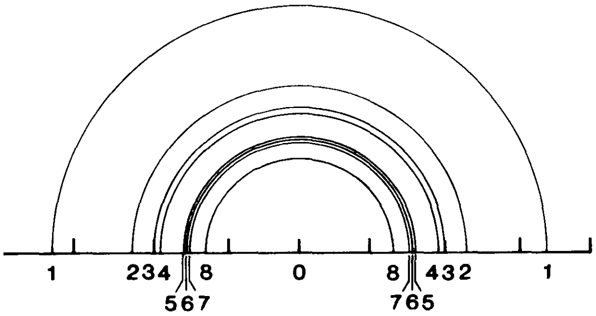

Figure 1. Simplified schematic half-circle representation of Uranium-238 radiohalo set. See Table I for explanatory data. Distance marks designate 10 micron intervals. Numbers designate set sequence.

Conclusion

A linear regression for the values of alpha-particle energy (E) in Mev and half-life (T) in years from Table I yields

$$\ln E = 1.678 - 0.01198 \ln T \qquad (3)$$

with a 0.985 coefficient of determination.

The energy of the emitted alpha particle, as well as the probability (half life) for the emission process, is determined by the relationship between long-range and short-range attractive forces between nucleons and the Coulomb (electrical) repulsive force between the nucleons which are protons. The stopping distance (range) for alpha particles emitted from atomic nuclei is determined by the magnitude of the electrical interaction between these alpha particles and the protons (repulsion) and electrons (equal attraction) in the surrounding medium. This magnitude is determined by the intensity of interaction with adjacent individual protons and electrons, and by the electric field which represents the combined influence of the more distant proton and electron distribution patterns in the medium. In solids the proton and electron distribution pattern is determined by electrical binding forces.

Electrical interaction is involved in both the emission and the stopping of alpha particles. Nuclear long-range and short-range attractive forces are involved only in their emission. Compensatory changes in these three forces can be postulated that result in a large change in the half-life but no change in the alpha particle penetration distance associated with one radioisotope. For reasoning confined strictly to the physical evidence at hand it seems highly unlikely that changes in the basic natural laws for these three forces (interactions) could be compensatory for large changes over the complete range of half-life and alpha energy of all the alpha particles produced by spontaneous nuclear transmutation. The most straightforward conclusion is that radioisotope half lives and the basic laws (patterns and magnitudes) of physical behavior have not changed over the time geological formations have been in existence, and probably have not changed throughout the history of the universe.

Such conclusions do not apply to circumstances such as a creation or a miracle in which God's activity is manifest differently than in the ongoing manifestation given by the regular operation of the universe. One can propose, or attempt to conceive, circumstances in which nuclear decay rates were altered dramatically while the penetration range of decay products remained unchanged. But sound creation science requires recognition that within the limitations of the currently available data such circumstances have support only from an interpretation of religious source material. Sound creation science seeks harmony between the revelation of God in the ongoing phenomena available for critical investigation (such as radiohalos) and the revelation of God in the Bible (particularly the accounts of Creation Week, the Noachian Flood, the miracles of the Exodus, and the miracles of Christ). While a presentation such as this may propagandize a personal view concerning what is truth, according to my perspective its primary function is to assist the reader in achieving what for him is the most fruitful harmonization of God's works and God's Word. I share the analysis in this paper in trust that it will increase appreciation for both God's works and His Word.

Acknowledgments

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QUOTE

Duhem is usually classed among the late nineteenth-century "Positivists," who are not to be confused either with the positivistic movement founded by Comte or the later (and still influential) school of "Logical Positivists," founded in Vienna and characterized by such men as Schlick and Carnap. Instead, Duhem is classed with men who like himself were practicing physicists, namely Ostwald and Mach, who also came to the conclusion that physical theories were not to be seen as descriptions of reality, but rather as "short-hand" notations used by physicists to classify or to summarize experimental evidence. These men were more aware of the history of physics than their colleagues, and thus aware of the many different ways that scientific evidence and empirical laws could be explained by different theories.

Caiazza, John C. 1988. Book review of Uneasy Genius: The Life and Work of Pierre Duhem. *Modern Age* 32:155.