A Classical Model for the Nucleus

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WHEN the cube root of the mass number is plotted against the square root of the atomic number for the most abundant or longest lived isotope of the elements, there is obtained a very nearly straight line extending from the neutron to curium. Hydrogen and helium are the only elements appreciably off of the line. The equation is $M^{1/3}-1.15=0.528Z^{1/2}$. To show this more accurately, $(M^{1/3}-1.15)^2$ is plotted against the atomic number in Fig. 1.

Assuming nuclei spherical, made of protons and neutrons each of radius r_0, with the protons confined to the outside giving a constant surface charge density at a depth xr_0 below the surface, we have:

$$4\pi(r-xr_0)^2=K_1Z\pi r_0^2 \quad \text{and} \quad 4/3\pi r^3=K_2M4/3\pi r_0^3,$$

where M is the mass number and Z is the atomic number. Combining gives

$$M^{1/3}-\frac{x}{K_2^{1/3}}=\frac{K_1^{1/2}}{2K_2^{1/3}}Z^{1/2}.$$

Use of $K_2=1.35$ as for spherical close packing gives $x=1.28$, and $K_1=1.36$. The correction factor for K_1 to get a value of K_1 corresponding to the middle of the surface particles, depends on M and Z. For holmium, for example, $M=165$, $Z=67$, and the surface $K_1=1.66$. If the surface contained equal numbers of protons and deuterons in hexagonal close pack the surface constant would be 1.65. This surface with each neutron surrounded by six protons, and each proton surrounded by three neutrons and three protons, we will call the surface pattern for stability.

The model of the nucleus to fit these observations is that of a positively charged chunk of solid hydrogen.

This model provides an explanation for many of the observations of nuclear physics, and leads to the prediction of new effects.

According to this model, α-particle emission could result from union of two surface deuterons to produce an α-particle with the 24-Mev reaction energy going into melting the nucleus, and setting it into pulsations. These pulsations could increase the surface, concentrating charge at the ends to eject the α-particle. The distortion needed to free the α-particle would determine its energy and the lifetime of its parent.

The model of a neutron to fit this picture is a subnuclear proton, with electron and neutrino rotating about it. If the neutron is radioactive, the maximum mass of the neutrino would be 0.00080 atomic units. The exact mass should be determinable by photo-ionization of neutrons.

β^--emission could result when a neutron disintegrates either spontaneously, or through photon-absorption, with ejection of β^{-1} and neutrino in the same direction. The freezing of the nucleus could transfer energy to vibration of a proton to give the photon for β^--emission. γ-radiation could be associated with rotation of a distorted non-rigid nucleus following α—emission, or of a rigid nucleus following β^--emission. Guggenheimer showed that γ-rays were like radiation of a rigid rotator.[1]

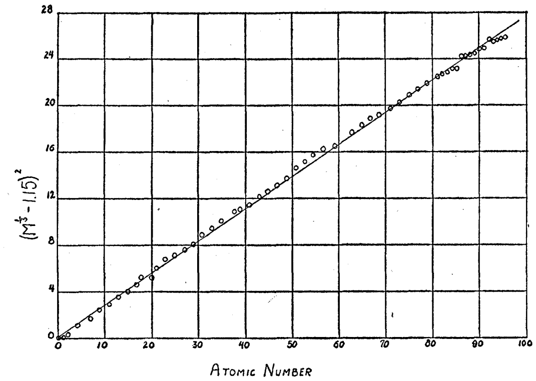

FIG. 1. Atomic number.

According to this model, the packing fraction of heavy nuclei could be high because of mutual repulsion of protons. Fission could result from splitting a near-perfect crystalline nucleus by a neutron. Heavy nuclei should serve as crystals for diffraction of high energy photons. Nuclei bombarded by high energy electrons should give electronic γ-ray spectra.

The concept of nuclear particles as close packed spheres leads to a model for light nuclei as flat, with thickness $2r_0$. According to this model the primary constituents of the nucleus are protons, deuterons, and neutrons. Double neutrons, corresponding to H_2 molecules, should be observable. Heavy atoms bombarded by deuterons, might form stable, heavier atoms. Very heavy nuclei could exist.

If this model of the nucleus is correct the properties of isotopes should be predictable from models treating the nucleus as a rigid rotator and as a polyatomic molecule.

[1] K. M. Guggenheimer, Proc. Roy. Soc. **A181**, 169 (1942–43).

Cosmic-Ray Bursts in an Unshielded Chamber and Under One Inch of Lead at Different Altitudes*

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THE original purpose of this experiment was an investigation of the altitude dependence of *high energy* electrons and photons in cosmic rays. Such an investigation provides a much more critical test for the various hypotheses on the origin of the electron-photon component than a study of the *total intensity* of this component.

The instrument used was a cylindrical ionization chamber three inches in diameter, twenty inches in length, filled with pure argon at 4.7 atmospheric pressure. The axis of the chamber was kept horizontal. The chamber was connected to a fast pulse amplifier, and the pulses were analyzed by means of a four-channel electronic discriminator. A weak polonium source of α-particles (5.3 Mev) was placed in the chamber for the purpose of calibration.

Measurements were taken both with, and without a lead