show that these fragments possess the same charge to mass ratio. They therefore conclude that the mechanism of splitting a crystal will not account for fission, and that the charge cannot be considered as residing on the surface of the nucleus.

The objection raised by Davison and Watson on the grounds that fission fragments have equal charge to mass ratio seems not to be valid, since the fragments which are observed after fission are observed a long enough time after the splitting to permit a reorganization of fragments to obtain the charge to mass ratio corresponding to the resulting radioactive isotopes. The rearrangement of fragments may be considered to begin as the fragments start to separate. They can thus contribute their change in mass defect to the kinetic energy of the fragments.

The crystalline-solid model offers a ready explanation for the fact that splitting occurs into fragments of unequal mass. If a nucleus of uranium (235) or plutonium (239) is considered as made up of nuclear particles in spherical close packing, then a crystal so formed can be considered as consisting of a central plane of symmetry with nuclear particles above and below in equal numbers, and with protons above and below the plane as well as in the outside rim of the plane. A model for uranium or plutonium would provide approximately 20 or 22 protons around the edge of the central plane of symmetry.

If such a crystalline solid is split along a cleavage plane, it must be split above or below, but not through the middle of the plane of symmetry. This means that the fragments must have unequal rather than equal masses. The number of protons which would be required to be associated with the fragments is, for uranium (235), 36 and 56 for a clean split just above or below the plane of symmetry. This gives fission fragments krypton and barium. The number of neutrons in these two fragments would be such that the lighter fragment, krypton, would be left in a highly radioactive state and the heavier fragment, barium, would be left in a highly radioactive state after releasing about four neutrons. The various fission fragments observed could be associated with the splitting of the crystal with various parts of different planes going with the separate fragments.

Another aspect or property of nuclei which also indicates that the nucleus may be considered as a crystalline solid is illustrated in Table I. In this table are listed the atomic numbers of the elements which have a given number of stable isotopes. Many elements consist of only a single isotope. All of these elements have an odd atomic number and an odd mass number. The elements of odd atomic number never have more than two stable isotopes, while the elements of even atomic number may have several isotopes. In Table I it is shown that atoms may be arranged in periods, where in some periods the multiplicity of stable isotopes alternates between one and several. In other periods it alternates between two and several. The known stable isotopes then form a periodic system shown in Table I. In this periodic system there are five periods in which, with successively increasing atomic number, the number of stable isotopes alternates between one and several, and these periods are six atomic numbers long. There are four periods, also six atomic numbers long, in which the number of stable isotopes alternates between two and several. There are three periods, each eight atomic numbers long, in which the number of stable isotopes alternates between two and several. All the elements fit into this periodic system except atomic numbers 4, 71, 73, and 83. According to this table it is to be expected that these elements, which are listed as having only one stable isotope,[3] may be expected to have two stable isotopes.

TABLE I. Number of stable isotopes for a given atomic number. s=several—two or more.

1	s	1	s	1	s	1	s	2	s	2	s	1	2	s	2	s	2	s	2	s	1
													1	2	3	4?	5	6	7	8	9
9	10	11	12	13	14	15	16	17	18	19	20	21									
21	22	23	24	25	26	27	28	29	30	31	32	33									
						33	34	35	36	37	38	39									
39	40	41	42	43	44								45	46	47	48	49	50	51	52	53
53	54	55	56	57	58	59	60	61	62	63	64	65									
65	66	67	68	69	70								71?	72	73?	74	75	76	77	78	79
						79	80	81	82	83?											

The periodicity of six in atomic nuclei, as shown in Table I, as well as the existence of elements of odd atomic number with only one or at the most two stable isotopes is readily accounted for on the basis of a crystalline-solid model for the nucleus. We may consider that the plane of symmetry of the nucleus contains an odd number of protons. Those elements which consist of only a single stable isotope may be considered as the ones with perfect symmetry of both mass and charge about the plane of symmetry containing an odd number of particles. Elements which contain several stable isotopes may be considered as those which are not perfectly symmetrical in both mass and charge, and can contain, for a given number of protons, a variable number of neutrons.

[1] J. G. Winans, Phys. Rev. **71**, 379 (1947).
[2] B. Davison and W. H. Watson, Phys. Rev. **71**, 742 (1947).
[3] J. M. Cork, *Radioactivity and Nuclear Physics* (Edwards Brothers Inc., Ann Arbor, Michigan, 1946), Table of Isotopes.

X-Ray Wave-Length Standards

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X-RAY wave-lengths have been expressed in x units. The x unit is defined in terms of the calcite spacing and is nearly 10^{-11} cm, but is now known to differ from 10^{-11} cm by about 0.2 percent. During the last twenty-five years x-ray diffraction workers have expressed x-ray wave-lengths and crystal dimensions in terms of a unit which was $1000x$ units, but instead of calling it $1000x$ units have erroneously called it an Ångström unit. In recent years, the x-ray diffraction groups have agreed to use the term kilo x unit (abbreviated kx) in place of the incorrectly used Ångström unit, until agreement was reached on the

best conversion factor to use for converting from *kx* to Ångström units. Agreement on the factor has now been reached.

As secretary of the American Society for x-ray and Electron Diffraction, I have been instructed to call the attention of American x-ray workers to the following announcement which appeared in the January, 1947, issue of the Journal of Scientific Instruments. Because of its importance it is here reproduced in its entirety.

The Conversion Factor for kx Units to Angström Units

At the annual conference of the X-ray Analysis Group of the Institute of Physics in July 1946 it was announced that agreement had been reached concerning the factor for converting measurements in kx units to Ångström units. The factor agreed upon, after consultation with the American Society for X-ray and Electron Diffraction and Professor Siegbahn was 1.00202. This factor is probably correct to 0.003 percent. Since wave-lengths in *X*-units have been measured to an accuracy of 0.001 percent, the wave-lengths in Ångström units can be taken as accurate to 0.004 percent in general.

The following is a list of values of wave-lengths in Ångström units of certain emission lines and absorption edges in common use. The column headed $K\alpha$ gives the mean value of $K\alpha_1$ and $K\alpha_2$, $K\alpha_1$ being allowed twice the weight of $K\alpha_2$.

Current values of the physical constants, such as those quoted by Birge in the 1941 volume of the Physical Society's *Reports on Progress in Physics*, should be used in conjunction with these wave-lengths. In particular density ρ is given by the equation

$$\rho = 1.66020 \Sigma A / V,$$

where ΣA is the sum of the atomic weights of the atoms in the unit cell, and V is the volume of the unit cell in A^3.

	$K\alpha_1$	$K\alpha_2$	$K\alpha$	$K\beta_1$	Absorption edge
Cr	2.28962	2.29352	2.2909	2.08479	2.0701
Mn	2.10174	2.10570	2.1031	1.91016	1.8954
Fe	1.93597	1.93991	1.9373	1.75654	1.7429
Co	1.78890	1.79279	1.7902	1.62073	1.6072
Ni	1.65783	1.66168	1.6591	1.50008	1.4869
Cu	1.54050	1.54434	1.5418	1.39217	1.3802
Zn	1.43510	1.43894	1.4364	1.29520	1.2831
Mo	0.70926	0.71354	0.7107	0.63225	0.6197
Rh	0.61326	0.61762	0.6147	0.54559	0.5341
Pd	0.58545	0.58982	0.5869	0.52052	0.5090
Ag	0.55941	0.56381	0.5609	0.49701	0.4855

It is recommended that in any published work the values of the wave-lengths used should be explicitly stated.

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