JOURNAL NOTES

Cosmic Nuclei

The primary cosmic radiation consists of atomic nuclei of the chemical elements. Some of these nuclei are endowed with energies many thousand times larger than the particle energies obtained even with large accelerators. Atomic nuclei of hydrogen, helium, carbon, oxygen, etc., up to elements as heavy as iron, have been detected with sensitive photographic plates, and of these the nuclei of hydrogen are most abundant.

For 10,000 hydrogen nuclei one observes about 2500 helium nuclei, 90 nuclei of carbon, nitrogen, and oxygen, 16 nuclei of magnesium and silicon, and 8 nuclei heavier than sulfur but not much heavier than iron. These abundance ratios are of great interest since they may be compared with the abundance ratios of chemical elements in stars and interstellar matter as determined by astrophysical methods. They certainly have some bearing on the still open question: Where do the cosmic rays come from? If the cosmic ray particles originate near the sun we would expect that the abundance ratios of nuclei in the cosmic radiation reflect the chemical composition of the solar atmosphere. If cosmic rays are filling the whole space, even the space between galaxies, we may expect that these ratios reflect the chemical composition of matter at an early stage of the evolution of the universe. If cosmic rays are produced and kept within our own galaxy by magnetic fields, another factor which may affect the relative abundances of various nuclei will certainly be important: namely, the smashup of cosmic ray nuclei in collisions with atomic nuclei of interstellar hydrogen gas. These collisions would result in the production of some light nuclei, such as nuclei of lithium, beryllium, or boron, which are exceedingly rare in the atmosphere of the sun. A search for these rare nuclei therefore may help to decide whether or not the cosmic rays we observe today have journeyed within our galaxy for some million years already. H.L.B.

The Heavy Nuclei of the Primary Cosmic Radiation. By H. L. Bradt and B. Peters. *Phys. Rev. 77:54, January 1, 1950.*

Ultrasonic Absorption

Classically, absorption of sound waves in liquids was attributed to viscosity and heat conduction, with heat conduction playing a minor role. However, many non-viscous, nonpolar liquids, notably carbon disulphide and benzene, show an absorption at least 1000 times greater than expected from their viscosity. Other structural features of the liquid must be effective in causing absorption. At present, the main point of interest is the transfer of the sound energy to internal degrees of freedom of the liquid molecules and the consequent absorption because of the slowness of the energy exchange.

The present investigation used the optical method of Debye and Sears to determine the effect of dissolving small amounts of polystyrene in benzene or toluene, thereby producing great increases in viscosity. The almost complete independence of absorption and viscosity found by the author (*less* absorption than viscosity would predict) can be explained qualitatively in terms of the ease of transfer of ultrasonic waves by associated liquids or molecular groups as pointed out by Kittel. A similar lack of absorption *change* was found between pairs of liquids differing only in symmetry or bonding—such as p-xylene, o-xylene, or tetrachloroethylene, tetrachloroethane. All of them absorb more than could be expected classically, so the coupling between external translational and external rotational degrees of freedom could well be the cause since symmetry or bonding has no observable effect.

Eventually ultrasonic absorption and velocity measurements over a wide range of frequencies (~ 1 to 1000 megacycles) can provide much information about the structure of liquids and aid in the development of an adequate theory of the liquid state. G.W.H.

Ultrasonic Absorption in Liquids. By G. W. Hazzard. *J. Acous. Soc. Am. 23:32, January, 1950.*

Alpha-Emission

The first successful application of quantum mechanics in relation to the atomic nucleus was the satisfactory explanation about 20 years ago of the dependence of the half-life for alpha-particle emission on the alpha-energy and the atomic number (and radius) of the nucleus. The answer to another important question, namely, the dependence of the alpha-particle energy (and therefore the half-life) on the mass number and atomic number, so that these radioactive properties could be understood and predicted for any nucleus Z^A, was also sought from the beginning but with only limited success. The main difficulty in such an endeavor has been the lack of data, since only about 24 alpha-particle emitters, all members of the three natural radioactive series, were known as recently as 10 years ago.

Today there are about 100 heavy alpha-decaying nuclear species known, the additional ones coming mainly from the artifically produced transuranium elements, the recently prepared neptunium ($4n + 1$) radioactive family which is missing in nature, and the several newly found series of alpha-emitters which are collateral to the four radioactive families. The data concerning these species has made it possible to add a great deal to our knowledge concerning the above mentioned questions, that is to our understanding of the systematics of alpha-radioactivity.

With regard to the correlation between half-life and energy, it is now clear that the nuclei of the "even-even" type (even number of neutrons and even number of protons) conform well with the existing alpha-decay theory, but all nuclear types with odd nucleons show prohibited decay. The new data make it clear that the reason for this prohibition is not to be found in spin changes in the alpha-emission, as previously thought, but in the fact that the odd nucleon hinders the assembly of the components of the alpha-particle, consisting as it does of a pair of neutrons and a pair of protons. The correlation of alpha-decay energy in terms of mass number and atomic number shows that for each element the isotopes exhibit a regular increase in alpha-energy with decrease in mass number except in the region of 126 neutrons where there is a reversal due to the special stability, the "closed shell" character, of 126 nucleons. This reversal has the effect of creating a region of relatively low alpha-energy and long half-life at low mass numbers for such elements as astatine, emanation, and francium (atomic numbers 85–87) and possibly higher elements as had been noted already for bismuth and polonium. In this region of tightly bound nuclei with abnormally small nuclear radii the half-life for a given alpha-energy also is longer than usual, as expected on the basis of the quantum mechanical treatment.

The present state of the correlations makes it possible to predict with confidence the alpha-energy and half-life of the missing nuclei and even to predict the disintegration energies, and with less confidence the half-lives, of a number of the missing beta- and orbital electron capturing species in this region. Also, since the energy content of all of the nuclei above lead can be tied together by means of the data on the alpha-emitters, together with the information on the beta-particle emitters where the evaluation is at present more difficult because of lack of adequate data, it is now becoming possible to define the nuclear energy surface in this region. G.T.S.

Systematics of Alpha-Radioactivity. By I. Perlman, A. Ghiorso, and G. T. Seaborg, *Phys. Rev. 77:26, January 1, 1950.*

Light Scattering

The recent revival of interest in light scattering, initiated by Debye and others, is principally due to its usefulness for studying large molecules, such as those of proteins or synthetic high polymers. The general theory is complicated, but Einstein showed in 1910 that, when the dimensions of all scattering particles and the effective range of the forces between them are small compared to the wavelength, the scattering can be treated as a fluctuation phenomenon. This development made possible the calculation of the thermodynamic properties of liquid solutions (e.g., molecular weights, free energies of mixing, etc.) from measurements of turbidity, which can be made rapidly and accurately with modern apparatus.

Most of the existing experimental data, and also the commonly familiar theory, are restricted to one or two-component systems, but solutions of three or more components offer possibilities of obtaining additional thermodynamic information on the interactions between dissimilar molecules. To allow the interpretation of measurements in such systems, Einstein's theory has here been extended to mixtures of arbitrary complexity by a straightforward application of fluctuation theory as developed by Gibbs in his treatment of grand canonical ensembles. Since completion of this work, it has been learned that Zernike long ago made the same developments (which were virtually inaccessible to American readers), and that Kirkwood and Goldberg currently have also repeated the work. The results are therefore not new, but simply cast existing theory into forms convenient for application. W.H.S.

Light Scattering in Multi-Component Systems. By W. H. Stockmayer, *J. Chem. Phys. 18:58, January, 1950;* Light Scattering Arising from Composition Fluctuations in Multi-Component Systems. By J. G. Kirkwood and R. J. Goldberg, *J. Chem. Phys. 18:54, January, 1950;* F. Zernike, *Dissertation, Amsterdam, 1915.*

Nuclear Magnetism

The measurements of magnetic properties of nuclei have progressed so far that it is already possible to draw some conclusions as to the distribution of magnetism within an atomic nucleus. It is shown in the present paper that the measurements on the magnetic moment of the rubidium nucleus give slightly different results when measured with the two standard methods (the direct measurement of the magnetic moment in a molecular beam, or the indirect measurement of the magnetic moment by its influence upon the spectral lines of the atom). The essential step in the first method consists in measuring the energy which is necessary to turn the Rb nucleus around in a magnetic field supplied by a strong magnet. The second method uses the so-called hyperfine structure of spectral lines which reflects the effect of the magnetic field of the nucleus upon the electronic orbits in the atom.

It is shown that the influence of the magnetic moment upon the hyperfine structure depends to some degree on the distribution of magnetism within the nucleus, since the electron density varies considerably over the nuclear volume and hence also the interaction with the electron. Investigations have shown that the distribution of magnetism is considerably different within the two isotopes of Rb. It was attempted in the paper to connect this difference with the fact that the magnetic moment of the Rb isotopes is made up in different ways of orbital motion and intrinsic magnetism of the nucleus; a fact which was pointed out earlier by Schmidt and others.

It seems that the refinement of measurements of magnetic moments provides a new tool to investigate finer details of the nuclear structure. No longer is nuclear magnetism measurable only by its magnetic dipole moments, for we now have the possibility of determining the distribution of magnetism within the nucleus. V.F.W.

The Influence of Nuclear Structure on the Hyperfine Structure of Heavy Elements. By Aage Bohr and V. F. Weisskopf, *Phys. Rev. 77:94, January 1, 1950.*

Radar

Although radar waves have been used primarily for detection and communication purposes, they may also be used in a variety of other experiments, including investigations which overlap or extend optical experiments. In particular they may be used to study diffraction prob-