function of under-cooling for a crystal in which the binding forces act between neighbouring atoms only. This compares well with the measurements.

M. v. Laue gives a study of the thermodynamics of supra-conductors, F. Hund the theory of diamagnetic properties of very small pieces of metal at low temperatures. The heat anomalies found for alums at very low temperatures by Simon and his co-workers are attributed to the internal electric and magnetic fields of the crystal acting on the trivalent metal ion by P. Debye in a paper on cooling by adiabatic demagnetization. A detailed discussion of the iron-ammonium alum gives the Curie point at 0.038°K. as against the value 0.034°K. given by

Simon from his observations. The magnetic coupling of the atoms leads to the formation of spontaneous order below a temperature of some thousandths of a degree, and prohibits a further cooling by demagnetization, which therefore will only be possible by action on the magnetic moments of the nuclei.

(6) Limitations of space forbid mention of further papers, save one by K. Schmeise and W. Bothe on a new kind of ultra-hard cosmic ray shower which seems to originate in the hard component of the primary cosmic rays. These showers scatter over an angle of about 10° , half that of normal showers, and are transformed into the ordinary soft showers on passing through matter.

The Problem of Stellar Energy

THE problem of stellar energy was the subject of discussion of the Fourth Annual Conference on Theoretical Physics sponsored by the George Washington University and the Carnegie Institution of Washington, and held in Washington, D.C., on March 21-23. The Conference was attended by astrophysicists studying the internal constitution of the stars (S. Chandrasekhar, B. Strömberg, T. Sterne, D. Menzel and others) as well as by physicists working on different branches of nuclear physics (H. Bethe, G. Breit, G. Gamow, J. v. Neumann, E. Teller, M. Tuve, L. Hafstad, N. Heydenburg and others).

On the fundamental problem concerning the nuclear transformations as the source of energy of stars, some interesting conclusions have been reached. According to the so-called "aufbauhypothese", the process of the building up of the heavier elements from hydrogen is continually taking place in stellar interiors. Further, it is assumed that such processes liberate sufficient amounts of energy to account for the radiation of the stars. However, it seems that the model scheme proposed by von Weizsäcker ($\frac{1}{2}\text{He} + \frac{1}{2}\text{H} \rightarrow \frac{3}{2}\text{Li} \rightarrow \frac{3}{2}\text{He} + \beta^+$) is contradicted by recent experimental evidence, according to which the nuclei $\frac{3}{2}\text{Li}$ and $\frac{3}{2}\text{He}$ are both unstable, emitting heavy particles in a very short time. Another possible chain of reactions for the synthesis of the heavier elements from hydrogen and helium would require the stability of $\frac{4}{3}\text{Be}$, which is again very doubtful according to recent experimental evidence. It appears, then, that the only course not excluded by present evidence on the binding energies of the light nuclei is the formation of $\frac{4}{3}\text{Be}$ in triple collisions involving an α -particle and two protons.

Although the existence of $\frac{4}{3}\text{Be}$ has not yet been established experimentally, there are some indications that it might be a stable nucleus. If so, the chain of reactions leading to the synthesis of the heavier nuclei from hydrogen can be traced. The estimate of the probability of such reactions involving triple collisions shows that, under the conditions in the stellar interiors, the rate of liberation of energy will be sufficient to account for the radiation of the stars.

As another possibility the reaction $\frac{1}{2}\text{H} + \frac{1}{2}\text{H} \rightarrow \frac{3}{2}\text{H} + \beta^+$ was suggested. It seems that the rate of such a reaction under the conditions in stellar interiors would be just enough to account for the radiation of the sun, though for stars much brighter than the sun other more effective sources of energy are required.

Special attention was directed to the possibility of resonance effects for nuclear reactions occurring in the interior of the stars; in such cases it would be necessary to consider that some light nuclei have virtual levels in the region of 10 kv. (corresponding to temperatures of the order 4×10^7 degrees Kelvin). The presence of resonance levels would not only increase the rate of liberation of energy of the reaction in question, but also would at the same time require a rather different type of stellar model. The rate of ordinary nuclear reactions increases exponentially with temperature, leading effectively to a point-source model in which the energy sources are concentrated at the centre. The selectivity with respect to temperature which would arise from resonance levels at about 10 kv. would, on the other hand, suggest a shell-source model with the maximum liberation of energy in a spherical shell surrounding the centre. It seems that this new model has a number of advantages over the point-source model.

The possibility of an extremely dense neutron core at the centre of the star (as proposed by L. Landau) was also discussed. The study of a number of known stars does not indicate a central condensation of more than what corresponds to 90 per cent of the total mass within half the radius. Thus, so far as astrophysical evidence is concerned, the model of a star with a heavy 'stellar nucleus' at the centre is not confirmed, except possibly for supergiants (for example, the *M*-component of $\nu\nu$ Cephei, the infrared component of ϵ Aurigæ), for which cases the observational evidence allows one to infer a high degree of central condensation corresponding to 90 per cent of the mass within less than ten per cent of the radius. Further, a stellar model with a 'nucleus' would require extremely high temperatures and densities ($\sim 10^9$ degrees and $\sim 10^9$ gm./cm.³) at the surface of the core. In such physical circumstances all nuclear reactions would occur at extremely high rates and the total liberation of energy would lead to predicted luminosities for stars of altogether different orders of magnitude from those observed. It was therefore concluded that stellar models with a concentrated nuclear core cannot represent real stars.

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