Attainment of Temperatures Below 1° Absolute by Demagnetization of $Gd_2(SO_4)_3 \cdot 8H_2O$

We have recently carried out some preliminary experiments on the adiabatic demagnetization of $Gd_2(SO_4)_3 \cdot 8H_2O$ at the temperatures of liquid helium. As previously predicted by one of us, a large fractional lowering of the absolute temperature was obtained.

An iron-free solenoid producing a field of about 8000 gauss was used for all the measurements. The amount of $Gd_2(SO_4)_3 \cdot 8H_2O$ was 61 g. The observations were checked by many repetitions of the cooling. The temperatures were measured by means of the inductance of a coil surrounding the gadolinium sulfate. The coil was immersed in liquid helium and isolated from the gadolinium by means of an evacuated space. The thermometer was in excellent agreement with the temperature of liquid helium as indicated by its vapor pressure down to 1.5°K.

On March 19, starting at a temperature of about 3.4°K, the material cooled to 0.53°K. On April 8, starting at about 2°, a temperature of 0.34°K was reached. On April 9, starting at about 1.5°, a temperature of 0.25°K was attained.

It is apparent that it will be possible to obtain much lower temperatures, especially when successive demagnetizations are utilized.

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The Equilibrium Theory of the Abundance of the Elements

It is possible by the theory whose development was announced[1] in a previous letter to calculate, for assemblies in which there is equilibrium regarding nuclear transmutations, not only the abundances of the elements but also the pressures and energies. One may draw conclusions from the theory concerning the fashion in which energy must be liberated in the stars by transmutations of nuclei, if the equilibria are there established. There is good reason for believing that these equilibria are in fact established inside of many stars, if not within all stars.

One immediate conclusion from the theory is that if all nuclei are composed ultimately of electrons and protons, then the most abundant element when equilibrium is established—for densities greater than 1 g/cm^3 and less than 10^6 g/cm^3, and at temperatures which are not too high—must usually be the element of even mass number and smallest packing fraction. The packing fraction of Fe^{56} has not yet been measured so far as I am aware, but it lies close to the bottom of Dr. Aston's curve of packing fractions; if iron^{56} has really the smallest packing fraction of all the "even" elements, then the abundance of iron in the stars, its great preponderance in many meteorites and its probable abundance inside of the earth can all be understood.

If a certain region in a star in which these equilibria are established is maintained at strictly constant temperature, then there can be no "generation" of energy by transmutations. If, however, the region cools at a rate so slow that the equilibria at any one instant are nearly perfectly established, energy will be liberated by the transmutations at a rate which can be calculated. The rate of liberation of energy is then proportional to the rate at which the region is cooling, among other things. The rate of liberation of energy, and the abundance of the elements, require for their computation a knowledge of the packing fractions of all of the isotopes of all the elements, the levels of nuclear excitation, and the spins of the nuclei in their normal and excited states.

The theory in the form of two detailed papers has been communicated to the Royal Astronomical Society, since it is considered that the *Monthly Notices* of that society is perhaps the most suitable place for the publication of the theory.

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April 13, 1933.

[1] T. E. Sterne, Phys. Rev. **43**, 585 (1933).

Surfaces from which Cold Emission Currents Appear Only at Very High Field Gradients

With a thoriated tungsten filament as the wire at the axis of a carefully shielded cylinder, currents were drawn from the wire after giving it various heat treatments. Curve A in the figure represents the current from the wire after it had been heated in the baking-out process during which the furnace was kept at 450°C for twenty-four hours and the plates were heated to a bright red by means of an induction furnace. The wire was then heated to 2000°K for thirty minutes after which curve B was obtained. The filament was again heated, this time to a temperature of 2900°K for thirty minutes after which treatment no measurable current appeared until the field was raised to 3.5×10^6 volts per cm at which potential gradient the current seemed to rise spontaneously from no measurable value to a current of the order of 10^{-4} amperes. A distinct glow accompanied this current. After this rise in current the curve D was taken without any further treatment. A rapid rise and the subsequent current curve at a lower potential gradient was reported by Bennett.[1] The wire was then heated to 2800°K for approximately one minute. This treatment shifted the curve to the position E. Bennett observed these break-