electron's motion around a loop may also fail at large geocentric distances, with a consequent sharp reduction of the Fermi acceleration and therefore of the intensity.

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ION TEMPERATURE IN SCYLLA, AS DETERMINED FROM THE REACTION D(d,p)T*

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Scylla, the Los Alamos experiment on fast magnetic compression of a plasma, has been shown to produce about 10^7 neutrons per pulse from the reaction D(d,n)He^3.[1] An equivalent ion temperature of about 1 kev corresponding to this yield can be computed, using our measured values of the plasma density ($6\times10^{16}/cm^3$), volume of the emitting region (3 cm^3), and mean duration of the neutron pulse (0.9 μsec). As has often been remarked, however, temperatures based on the reaction rate alone deserve little credence until the rate is so high as to be inexplicable on any other assumption than the thermal one. The present experiment was designed to measure in a more direct way the ion temperature. By studying the velocity spectrum of products of the reaction D(d,p)T we measure the mean square velocity of the center of mass of the d-d system, and hence the temperature of the plasma. We find in this way $T = 1.3$ kev. The spectrum obtained, coupled with the result that the neutrons emitted in the radial direction showed no Doppler shift on reversing the applied field,[1] argues strongly against many of the mechanisms for spurious neutron production which have been proposed. Radial hydromagnetic shocks having speeds of 15 cm/μsec are observed at the time of zero external magnetic field. It is easy to account for the measured final ion temperature with a model in which the plasma is adiabatically compressed after being preheated by the shocks. The assumption that the plasma is completely diamagnetic leads to the numerical result that the particle pressure is in balance with the confining magnetic field.

For a plasma of temperature T, the specific reaction rate is $\langle\sigma v\rangle_{\rm Av}$, namely the reaction cross section times the relative velocity averaged over a Maxwell distribution. The velocity spectrum of the protons depends on v_0, the minimum velocity of emission of a proton in the center-of-mass system, on kT, on the particle masses m_p, m_d, and m_t, and on the Q value of the reaction. We derive for the number of protons per unit energy interval

$$dN/dE = \left(\frac{m_d}{4\pi kT}\right)^{1/2} (n_d^{\,2}\langle\sigma v\rangle_{\rm Av}/m_p v_0) \times \exp\left\{-\left[\frac{m_d}{kT}(v-\bar{v})^2\right]\right\},$$

$$\bar{v} = v_0\left(1 + \frac{kT}{2Q}\,\frac{d\ln\langle\sigma v\rangle_{\rm Av}}{d\ln kT}\right)$$

For protons

$$m_p v_0^{\,2}/2 = m_t Q/(m_p + m_t),$$

and for tritons the subscripts p and t are interchanged. By measuring the width of the velocity distribution of the products we obtain a value for T.

The axial direction was chosen because no windows in the discharge tube are required, and because the interpretation is simpler. The rest of the geometry was fixed by the parameters of a magnetic spectrograph which was available. Figure 1 shows in cross section the experimental

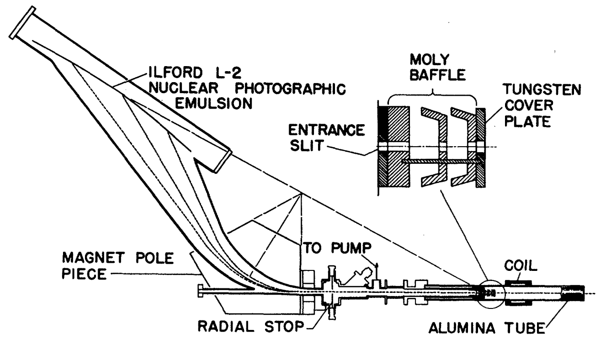

FIG. 1. Experimental arrangement. The discharge occurs within the alumina tube at the center of the coil. The dashed lines represent trajectories of the protons and the tritons from the *d-d* reaction.

arrangement. The Scylla discharge takes place inside the alumina tube. The spectrograph entrance slit is placed as close as possible to the discharge, namely 10 cm. The slit, if too near, is damaged by heat and wall material which strike it during late stages of the discharge. The slit forms the object for the ion-optical system, and the dispersed image is formed on the nuclear emulsion.

Two runs were made with the spectrograph and charged particles from Scylla. A thin cover was used to protect the emulsion from scattered light. In the first exposure the cover was 1.0 mg/cm^2 of (aluminized) polyester film; this effectively stopped the tritons, but left the protons with about 67 microns residual range. In the second exposure the cover was 0.55 mg/cm^2 of nickel; this allowed the tritons to enter the emulsion with a residual range of about 5 μ. The first exposure was 1617 discharges of Scylla, the second 1888, and the corresponding total numbers of neutrons emitted, as measured by a silver counter, were 1.0×10^{10} and 1.1×10^{10}. The plates after development showed tracks which were easily identified as the *d-d* protons or tritons, respectively. The density of tracks when plotted vs position revealed smooth distributions whose maxima came at the predicted locations. The width of the curve in the least favorable case was three times the resolution of the instrument and in the most favorable case eighteen times the resolution. The resolution and energy calibration were measured by means of an exposure to a thin source of Pu^{240} alpha particles. The track location fixes the particle velocity, and the number of tracks per unit length along the plate is converted into number of particles per energy interval coming

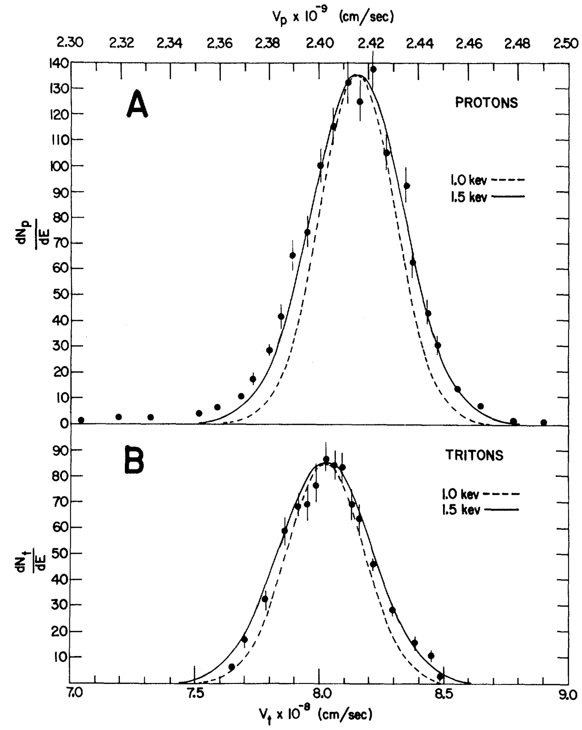

FIG. 2. Velocity spectra of protons and tritons from the *d-d* reaction in Scylla. The solid and the dashed curves are computed with the expressions given in the text. The width of the triton curve is eighteen times the measured resolution of the spectrograph.

from reactions in the plasma. The conversion takes into account the variations along the plate of angle of entry into the emulsion and of lateral magnification. Figure 2 shows the reduced distribution dN/dE for the second exposure. The curves are computed ones using the equation for dN/dE for $T=1.0$ and $T=1.5$ kev. A temperature of $T=1.3$ kev is in agreement with these data and with similar data from the other exposure. The agreement of $\bar{v}$ with predicted values is as follows: for the protons 2.410×10^9 cm/sec predicted, observed 2.412×10^9 cm/sec, and for the tritons 0.8047×10^9 cm/sec predicted, observed 0.8041×10^9 cm/sec. This agreement indicates that the plasma has negligible mass motions in the axial direction. The principal uncertainty in the interpretation of the distributions is introduced by the low-energy tail to the proton distribution; however, this involves only about 1.5% of the reactions.

A more complete discussion of this experiment is being prepared for publication.

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TWO MASER EXPERIMENTS TO TEST GENERAL RELATIVITY

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Despite the fact that special relativity is firmly established on experimental grounds, the same cannot be claimed for the general theory. First of all, there are only three experimental tests of general relativity and not all of them are sufficiently conclusive in favor of the theory. (*i*) The bending of light rays, though correct as an order of magnitude, is just outside the experimental error. (*ii*) The observed shift of spectral lines towards red is qualitatively in agreement with the theory but a quantitative agreement is still a much discussed and investigated question. (*iii*) In the case of the advance of the perihelion of Mercury, the situation is different. Here, we have a satisfactory quantitative confirmation. Until recently, it was thought that the advance of the perihelion of Mars was not correctly predicted by the theory.[1] In the last few years, more elaborate calculations have shown that the theory predicts the effect within the observational error.[2] The calculations for the Earth's perihelion are at present in progress, but preliminary calculations are in agreement with the theory. It must be remembered that the perihelion motion is a second order effect and its quantitative agreement lends great support to the theory. Nevertheless, one cannot say that these facts provide sufficient tests for such a fundamental physical theory as general relativity. There is definite need for further practicable experiments in the field of gravitation. This need is being felt all the more strongly as time goes on because of man's increasing interest in space and gravitation.

In this note, two closely related but essentially different experimental tests of the theory are discussed. Only a year ago, it would have been impossible to carry them out. Thanks to the recent advances in maser techniques, these experiments can now be done without too much difficulty.[3]

The first experiment[4] provides a direct test for the principle of equivalence. As is well known, according to the principle of equivalence, the effects of an external gravitational field in a local coordinate system (say a small material box) can be eliminated completely by letting the coordinate system be free in that gravitational field (freely falling box). In such a coordinate system, the external gravitational field does not have any influence either on the motions of particles or on any other physical process whatever. Thus, according to the principle of equivalence, such a system must locally be equivalent to a Lorentz frame and in it, light rays must travel with the same velocity in all directions. Now, in the gravitational field of the Sun, our Earth may be considered as a small box and the above statement concerning the local propagation of light may be tested by comparing the velocity of light in the direction of the line joining the Earth and the Sun and in a direction perpendicular to it and the Earth's radius (Fig. 1). Nowadays, maser techniques are approaching an accuracy $\delta c/c \simeq 10^{-12}$ (c is the velocity of light) in comparing the two velocities.[4] If a discrepancy is found to this accuracy, it would imply a deviation from the principle of equivalence in first