magnitude at maximum less than 6. The mean absolute magnitude at maximum appears to be about -5, which gives apparent magnitude 6 at 5,166 light years distance. Hence we should certainly not underestimate E if we suppose there is one nova per year at distance $r = 5{,}000$ light years, and that this one is solely responsible for the cosmic rays in our neighbourhood. This would give an average energy flux $F = E/4\pi r^2 Y$ per cm.² per sec. outside the earth's atmosphere, where $Y = 3{\cdot}156 \times 10^7$ sec. = 1 year. This does not imply that a nova outburst lasts on the average just one year; it gives merely an estimate of the rate of supply of cosmic ray energy if one nova appears per year at distance r. Further, Regener[2] has estimated the flux of cosmic ray energy outside the atmosphere to be $3{\cdot}53 \times 10^{-3}$ erg./cm.²/sec. Setting F equal to this value, we find $E \sim 3 \times 10^{49}$ ergs. This should be an upper bound; and it should be safe to conclude that if a single nova is capable of liberating energy of this order, then, so far as energy considerations go, such processes could maintain the observed intensity of cosmic rays.

Now Milne[3] takes a typical nova outburst to be one in which a star of initial effective temperature $T_0 \sim 8{,}000°$ collapses to a state of final effective temperature $T \sim 40{,}000°$. Also he takes the total luminosity as about the same before and after collapse, so that $R_0 T_0{}^2 = RT^2$, where R_0, R are the initial and final radii. If then we take a star having initially solar dimensions, its initial negative gravitational energy is on Eddington's model $5{\cdot}66 \times 10^{48}$ ergs. This quantity is inversely proportional to the radius, so that if the radius changes in the ratio $(R_0/R) = (T/T_0)^2 = 25$, then its final value is $1{\cdot}42 \times 10^{50}$ ergs. Hence the total gravitational energy liberated in the collapse is $\sim 10^{50}$ ergs. This estimate was first given by Milne[4], and is independent of any theory of what happens during the actual outburst. Nevertheless, he does not consider that such a large energy liberation can in fact take place, for on his stellar models the mass is much more concentrated towards the centre than in Eddington's, so the potential energy change corresponding to a given radius change is smaller. Hence it appears that if stars are built on Eddington's model, then it may be possible that nova outbursts are adequate to supply the energy of cosmic rays. Whether the gravitational energy is liberated in the form of cosmic rays or not, is of course another question. If, however, the stars have much higher central densities, then apparently the energy supply from this source would not suffice.

A more definite verdict can at present scarcely be given. One needs to know more about the structure of a star just before and just after the nova phase, and more about the distribution of novæ in space. In regard to the latter, it may however be pointed out that Kolhörster tentatively connects a 2 per cent increase in cosmic ray intensity with Nova Herculis. Since estimates of the total number of novæ in the galaxy give 20–30 per year, he considers this fraction not unreasonable if novæ have the importance suggested. However, almost all these novæ are much fainter than Nova Herculis, which should therefore make a much *larger* percentage difference.

Finally, it need scarcely be said that if the origin of cosmic rays is to be traced to novæ, then their liberation of energy in this form must vastly surpass that in the form of light. For Regener's estimate gives a cosmic ray intensity almost equal to the total intensity of starlight. The latter is equivalent to the light from about 2,000 first magnitude stars, while a nova rarely reaches first magnitude, and so makes but little difference to the total light intensity. Actually, Unsöld has evaluated the total light emitted in a typical nova outburst as 6×10^{44} ergs, a quantity small compared with the order of 10^{49} ergs seen to be necessary for cosmic rays.

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Ratio of the Magnetic Moment of the Proton to the Magnetic Moment of the Deuteron

IN a previous paper[1] it was shown that it is possible to estimate the ratio of the magnetic moment of the proton to the magnetic moment of the deuteron (μ_H/μ_D) by comparing the rates of the reactions

$$\text{ortho-}H_2 + O_2 \rightleftarrows \text{para-}H_2 + O_2 \qquad (1)$$
$$\text{ortho-}D_2 + O_2 \rightleftarrows \text{para-}D_2 + O_2 \qquad (2).$$

The ortho-para transitions occur in the reactions (1) and (2) under the influence of the inhomogeneous magnetic field during the collisions with oxygen molecules[2].

Since the theory of the paramagnetic ortho-para-hydrogen conversion[3] has recently been investigated in some detail[4], and in addition more heavy hydrogen has become available, the ratio μ_H/μ_D has been re-determined. The results obtained are given below.

Temperature T (° K)	$k^{(2T)}_{H_2} / k^{(T)}_{D_2}$	μ_H/μ_D
83	12·5	3·85
193	14·5	4·03
293	14·8	4·07

$k^{(2T)}_{H_2}$ and $k^{(T)}_{D_2}$ denote the velocity constants for the reaction (1) at the temperature $2T$ and that for the reaction (2) at the temperature T respectively. The ratio μ_H/μ_D is calculated according to the formula given by Kalckar and Teller[4].

$$(\mu_H/\mu_D)^2 = a.k^{(2T)}_{H_2} / k^{(T)}_{D_2}$$

where $a = 9/8 = 1{\cdot}12$ for $T > 120°$ K. and $a = 1{\cdot}18$ for $T = 83°$ K. The variation of the ratio μ_H/μ_D with temperature is within the limits of experimental error, which is less than 5 per cent.

The present ratio is in agreement with the values for μ_H and μ_D obtained by the magnetic deflection method[5,6]. It should be mentioned, however, that the ratio μ_H/μ_D as determined by the deflection method is not very certain owing to the great limit of error in the measurement of the absolute values for μ_H and μ_D.

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(*Continued on p.* 393.)

Experimental Evidence regarding the Field of the Deuteron

A METHOD for determining the field surrounding nuclei is to scatter charged particles by the nuclei in question. If the field were of the Coulomb type, the yield of nuclei projected in a given direction under the bombardment of α-particles would be proportional to $1/V^4$, where V is the velocity of the incident α-particles. Any deviation from the Coulomb field will manifest itself in a deviation from this relation. The experiments of Chadwick and Bieler[1] have shown that such anomalous scattering is very clearly evident in collisions between α-particles and protons for α-particle velocities corresponding to ranges greater than about 2 cm.

We have made similar experiments to determine the range at which anomalous scattering begins for α-particle impacts (1) with protons, (2) with deuterons. Our results for protons confirm the work of Chadwick and Bieler and show detectable anomalous scattering at 1·7 cm. α-particle range for head-on collisions; experiments at a greater angle showed that the anomaly occurs at a larger range but for the same distance of closest approach. The yield curves for deuterons are of the same form as for protons, as suggested by Rutherford and Kempton[2], but the anomaly begins at a lower α-particle range, namely, 1·45 cm. for head-on collisions.

If one calculates the distance of closest approach for the two cases, taking account of the different masses of the projected particles, one finds that the deviation from the Coulomb field occurs at $4 \cdot 6 \times 10^{-13}$ cm. for protons and $3 \cdot 1 \times 10^{-13}$ cm. for deuterons. It is of interest that the attractive nuclear field extends farther in the case of the proton than it does in the case of the deuteron. If known corresponding radii for higher elements are plotted against Z, then it is the proton which lies off the extrapolated curve, the deuteron being more nearly regular.

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β-Spectra of Some Radioactive Elements

WE have investigated the β-spectra of radioactive elements that are obtained by bombarding chlorine, bromine and iodine with neutrons. As E. Fermi, E. Amaldi, O. D'Agostino, E. Rasetti and E. Segrè[1] have shown, in all these cases radioactive isotopes of the bombarded elements are formed.

A glass tube containing beryllium and 200 millicuries of radon was used as the source of neutrons. Surrounding the source with substances rich in hydrogen[2] highly increases in the case of bromine and iodine the probability of formation of the radioactive nuclei, and in the case of chlorine gives a marked effect[3]. Therefore we immersed the source, together with the sample to be irradiated, in a container filled with water.

Radioactive chlorine was observed by using carbon tetrachloride, and radioactive bromine and iodine were obtained from ethyl bromide and methyl iodide, the active atoms being separated from the irradiated substance, as suggested by Szilard and Chalmers[4], in the form of a thin layer of the corresponding silver compound.

The energy distribution of the electrons emitted was measured by the magnetic analysis method with two Geiger-Müller counters already described[5]. The results obtained are shown in the last two columns of the following table:

Irradiated substance	Radioactive substance	Period	Limit of the spectrum	Maximum of the spectrum
Chlorine	Cl^{36}	50 min.	2,050 ± 100 kv.	—
Bromine	Br^{80}	30 min.	2,100 ± 100 kv.	~ 500 kv.
Bromine	Br^{82}	6 hr.	2,100 ± 100 kv.	< 300 kv.
Iodine	I^{128}	30 min.	2,100 ± 100 kv.	~ 500 kv.

So far as the accuracy of our measurements goes, all the elements investigated have the same spectral limits. Furthermore, Br^{80} and I^{128} have not only the same periods and spectral limits, but also the same shape of the spectral curve, analogous to that of radium E. By comparing the spectral limits obtained here with the masses of the nuclei involved in the nuclear reactions, emission of hard γ-rays is to be expected.

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Ionosphere Measurements during the Partial Eclipse of the Sun of February 3, 1935

PULSE measurements were made at Deal, N.J., during the solar eclipse of February 3, 1935. This eclipse began at 10.28 a.m. and ended at 12.32 p.m. with a maximum effect at the ground at Deal of approximately 40 per cent magnitude at 11.30 a.m. (E.S.T.).

The critical ionisation frequencies for the E, M[1] and F_2 regions were measured on the day of the eclipse from 8.30 a.m. to 2.00 p.m. as well as on the two following days.

Our results show that the eclipse was accompanied by a decrease in the maximum ionic density of 20–25 per cent in all three regions, and that the minimum ionisation occurred at or very shortly after the eclipse maximum. The percentage decrease was progressively greater from the lowest to the highest region, being approximately 20 per cent for the E region, 22 per cent for the M region and 25 per cent for the F_2 region. A progressive increase of this order is to be expected from the fact that the eclipse had a magnitude of 40 per cent at the ground and approximately 43 per cent in the F_2 region (250 km. over Deal). These magnitudes are in terms of the sun's diameter, which for this eclipse means an eclipsed area of 29 and 31 per cent, respectively.

This decrease in ionic density may be compared to a 50–60 per cent decrease in the E region ionisation during the eclipse of August 31, 1932, when the eclipse magnitude was 95–100 per cent.

A number of observers[2] who made measurements during the 1932 eclipse agreed that while there may have been an eclipse effect in the F_2 region, it could not be definitely attributed to the eclipse in view of