Letters to the Editor

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Magnetic Variable Stars as Sources of Cosmic Rays

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RECENT observations confirm the variations in the general magnetic field previously reported for the peculiar A-type spectrum variable star HD 125248 (BD-18° 3789).[1] In a regular period of 9.295 days, the polar magnetic field changes from $+7800$ gauss to -6500 gauss and back. At maximum, the magnetic moment is roughly 2×10^{37} gauss cm^3, and the energy in the magnetic field is probably of the order of 10^{-6} of the kinetic energy of rotation. The well-known changes in line intensity[2,3] are synchronous with the magnetic cycle, the maximum for the Eu II lines coinciding with maximum positive magnetic intensity, and the maximum for Cr I and Cr II coinciding with maximum negative magnetic intensity. Many of the abnormal line intensities and their variations can be explained, at least qualitatively, in terms of Zeeman broadening of narrow, strongly saturated, absorption lines. (Some lines of Eu II attain an actual width of 0.35A in a field of 8 kilogauss and may have their total absorption increased by a factor approaching 8.) About a score of type A spectrum variables brighter than the sixth magnitude are known,[3] and the existence of magnetic fields of the order of a few kilogauss has been established in some of these by observations of the Zeeman effect;[4] it may be inferred that all of these spectrum variables have varying magnetic fields and that the magnetic variations are more fundamental than the changes in line intensity. In some of the closely related "peculiar" stars, constant but abnormal line intensities are found, together with a magnetic field that is constant within the observational error. An example is γ-Equulei (FO_p) with $H_p = 1900\pm 250$ gauss.[5]

Davis has shown that a rotating star having a dipole magnetic field of constant intensity 5500 gauss at the poles should develop a quadrupole electrostatic field with potential V_p at the poles of the order of 10^{14} volts.[6] He further showed that cosmic rays should be temporarily ejected with energy eV_p along the polar axis, but that accumulation of ions that do not move along the axis will produce a space charge that will invalidate the model and suppress further ejection of cosmic rays. The observed alternating magnetic field of HD 125248, on the other hand, now suggests that at certain phases the suppressing effect of space charge will be eliminated and that alternate ejection of positive ions and electrons through electrostatic repulsion from the polar regions will recur in parts of each magnetic cycle.

A distinctly different process is that proposed by Swann to account for the acquirement of cosmic-ray energies by electrons, according to which the circular motion of an electron in an increasing magnetic field (such as a sunspot in the growing stage) gives it a magnetic moment opposed to the increasing field and results in outward acceleration.[7] (This mechanism has been dubbed the "Cygnatron" by Vallarta.) It now appears unnecessary to invoke the existence of stellar spots as sources of energetic cosmic rays as suggested by Swann, although such spots may, in fact, exist.[8]

The observed variations in the general magnetic field of HD 125248 and of some other spectrum variable stars constitute evidence for specific sources of cosmic rays according to either or both of the processes mentioned.

The number and distribution of magnetically active stars within the galaxy is as yet unknown, but they seem not to be scarce. Calculation shows that the path of a 10^{10}-volt proton passing a star having a surface field of 1 kilogauss at a distance of 0.01 light year (700 astronomical units) will have a radius of curvature of the order of 30 l.y.; this is small compared to the radius of the galaxy (35,000 l.y.). Deviations of this nature should contribute to the randomness of direction of cosmic rays.

[1] H. W. Babcock, Pub. Astr. Soc. Pac. **59**, 260 (1947).
[2] W. W. Morgan, Ap. J. **99**, 258 (1944).
[3] A. J. Deutsch, Ap. J. **105**, 283 (1947).
[4] H. W. Babcock, Ap. J. **105**, 105 (1947).
[5] H. W. Babcock, Ap. J. (*in press*).
[6] Leverett Davis, Jr., Phys. Rev. **72**, 632 (1947).
[7] W. F. G. Swann, Phys. Rev. **43**, 217 (1933).
[8] G. E. Kron, Pub. Astr. Soc. Pac. **59**, 261 (1947).

Pulse Characteristics of Anthracene Scintillation Counters

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THE experiments of Bell and Davis[1] with regard to the superiority of anthracene for scintillation counters have been confirmed. In a representative arrangement, a transparent piece (1-in.$\times$1-in.$\times\frac{1}{4}$-in. in dimension) of this material is fastened to the wall of a 1P21 photo-multiplier, facing the photosensitive surface. When operating at room temperature at 70 volts per stage, individual pulses up to 0.5-volt height (corresponding to the emission of about 100 electrons at the photo-surface) are observed at the output, upon exposure to a standard radium source. The signal-to-noise ratio of about 5:1 remains essentially constant up to 120 volts per stage applied to the first two stages of the

1P21, beyond which voltage it falls rapidly; it is independent of the potential applied to the remaining seven stages. An over-all gain of 25 million is then achieved by operating stages one and two at 120 volts each, and stages three through nine at 180 volts each. Pulse heights of 20 volts and more are then observed, which are sufficient to feed directly into oscilloscopes, coincidence, mixers, etc., without recourse to additional vacuum-tube amplification.

Since upwards of 1500 volts appear between adjacent anode and cathode pins, certain precautions were taken, such as slotting the base and socket, and wax impregnation. Since the peak current in the last few stages is quite high, these were by-passed with small mica capacitors.

For visual pulse observation, the photo-multiplier was mounted at the neck of an oscilloscope tube of the 5JP1 variety, with very short connections. The signal pulses showed a finite rise time of about 0.05 microsecond; this figure represents the period over which appreciable light emission by the anthracene takes place, the photo-multiplier output circuit being effectively an integrator of the photo-electrons. Variation of the decrement of the output circuit (by changing the load resistor) showed that pulse height attenuation became evident for decrements lower than 0.15 microsecond, in agreement with the rise time observation. This figure is indicative of the resolution time to be expected in normal practice. It is significant that the rise time of noise pulses originating at the photo-surface is visibly much more rapid, having no observable slope, and is much less affected by the circuit decrement.

Typical values for the output circuit elements:

circuit capacitance—15 micromicrofarads
load resistance —10,000 ohms.

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[1] P. Bell and R. Davis, Bull. Am. Phys. Soc. 23, No. 3 (1948).

Cloud-Chamber Study of Meson Disintegration*

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We have recently obtained several cloud-chamber photographs at sea level showing mesons which come to rest and disintegrate. The apparatus is shown in Fig. 1. The cloud chamber (I.D. = 11 inches; illuminated depth = 3 inches) is filled with argon and ethyl alcohol to a total pressure of 100 cm Hg before expansion. A $\frac{1}{4}$-inch thick aluminum plate was placed across the diameter of the chamber to act as a slow meson absorber. The chamber is mounted between Helmholtz coils producing a field of 1680 gauss.

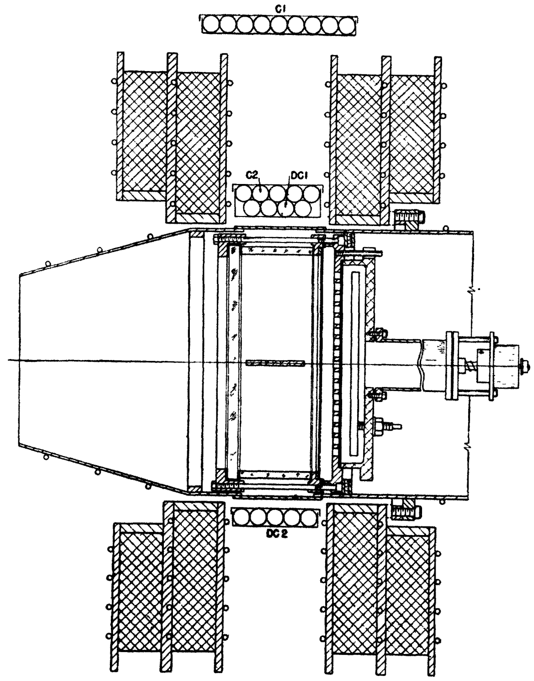

FIG. 1. Scale drawing of apparatus.

The counters are connected to a circuit which expands the cloud chamber when a simultaneous discharge in trays *C1* and *C2* is followed 0.7 μsec. to 4.7 μsec. later by the discharge of any one of the counters *DC*. This triggering arrangement heavily favors the detection of mesons which decay in or near the illuminated volume of the cloud chamber.

Figure 2 shows a positive meson which stops in the gas of the chamber after penetrating the plate. The track of the disintegration particle is clearly visible but is unfortunately short from the standpoint of curvature measurement.

We obtained six photographs showing positive mesons which stop in the plate. We also obtained a number of photographs in which heavily ionizing mesons which proba-

TABLE I. Momentum of the disintegration particle.

Film number	Sign of meson	Place of disintegration	Sagitta of track in mm	pc in Mev
77	+	plate	1.2	(20–50)
78	+	plate	3.3	42±12
84	−	glass	1.0	(70(?))
87	+	glass	3.5	53±15
89	+	gas	0.7	(20–50)
104	+	plate	3.5	43±9
106	+	plate	2.5	40±8
110	+	glass	1.5	(40±12)
111	+	plate	4.0	48±10
112	+	plate	4.0	42±8