Letters to the Editor

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On Polarization of Radiation by Interstellar Medium

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IT has been suggested by several authors that the polarization of the radiation from distant stars[1] is a consequence of elongated interstellar particles with axes pointing in a common direction.[2-4] It has been assumed that these particles were aligned by interstellar magnetic fields which are believed to exist[5] and which have been successfully employed by Fermi[6] in theoretical investigations on the origin of cosmic rays.

If the mechanism assumed above for the origin of interstellar polarization is correct then it must satisfy the observed characteristics of this polarization. The most stringent requirement is that the mechanism must predict the observed amount of polarization as a function of wave-length. If interstellar polarization is produced by the same particles as those that are responsible for interstellar absorption then it follows that interstellar polarization should show the same wave-length dependency as interstellar absorption which is known to be $1/\lambda$. The original observations of July, 1948, indicated that the amount of polarization is approximately independent of wave-length, in sharp contrast to interstellar absorption. It is important, therefore, that the spectral region be extended to more extreme wave-lengths than those originally employed.

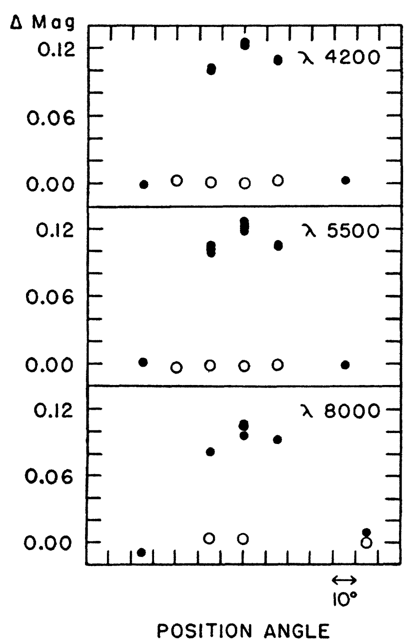

FIG. 1. Interstellar polarization of BD+62°643, closed circles, as a function of wave-length. Open circles refer to BD+40°500. The ordinates represent the change in intensity (expressed in magnitudes) when the Polaroid was rotated through 90°. See Astrophys. J. 109, 471 (1949) regarding the observational procedure.

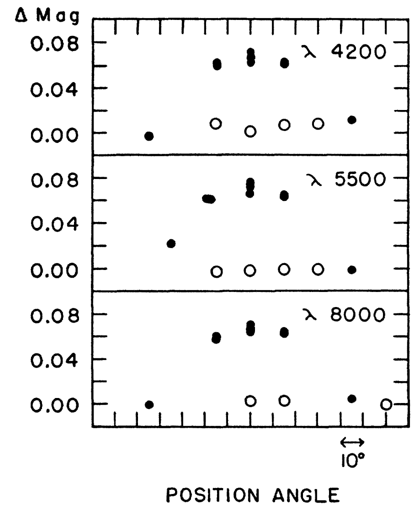

FIG. 2. Interstellar polarization of BD+58°607, closed circles, as a function of wave-length. Open circles refer to BD+40°500.

In December, 1949 observations were extended to the infra-red. A [Ag]$-Cs_2O$ photo-cell (Ce$-$25) was used in conjunction with H_D in a.c. Polaroid. The estimated effective wave-length is 8000A. Two stars were observed, BD+62°643 and BD+58°607, with BD+40°500 serving as a check star with an assumed zero polarization. The results of these observations are shown in Figs. 1 and 2. The observations at effective wave-lengths 4200A and 5500A were made with a 1P21 multiplier photo-cell with Corning filters No. 5850 and 3385 respectively.

It is obvious that interstellar polarization does not show the same wave-length dependency as interstellar absorption, that is, as $1/\lambda$, but, to a first approximation, is independent of wave-length. Since electron scattering is independent of wave-length, the question arises as to whether or not an orientation of electrons by an interaction of their spins on the assumed magnetic fields may be responsible for the observed polarization.

A lower limit for the number of free electrons N_e per cm^3 in interstellar space can be easily computed on the assumption that the electrons are uniformly distributed in space and that their spins are oriented in such a manner that the cross section, σ, for scattering of radiation has the value zero for one component and Thomson's value, $\sigma=8\pi e^4/3m^2c^4$ for the other. This assumption is an extreme one but it will provide a most favorable test for the idea. For the cluster h and χ Persei it has been observed that $\delta=0.075$. The accepted distance of this cluster is 1920 parsecs.[7] Consequently the minimum number of electrons necessary to produce the observed polarization is $N_e\sim 17$. This must be contrasted with the estimated $N_e\sim 3$ from other considerations.[8] While the latter estimate is uncertain, it is unlikely that it is in error by a large factor; indeed considerations relating to the dynamics of the galaxy would appear to rule out a value of $N_e\gg 3$.

Although the new material presented here is limited, it is difficult to ignore the somewhat smaller polarization of BD+62°643 at 8000A than at the shorter wave-lengths and the remarkable constancy of polarization with wave-length in the case of BD +58°607. If further observational material confirms the suggestion that the wave-length dependency of polarization is not entirely uniform from star to star then this may give a clue to the origin of the observed polarization. Van de Hulst[9] has shown that the law of interstellar reddening can be predicted by the proper size distribution and refractive index of the interstellar particles. It seems likely that the same procedure may be applicable to the prediction of the observed polarization as a function of wavelength.

It is a pleasure to thank Dr. Öhman for emphasizing the importance of extending the observations to more extreme wavelengths, and Drs. S. Chandrasekhar and O. Struve, for valuable discussions.

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Measurements of the Influence on the Fountain Effect of He^3 Dissolved in He^4

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HELIUM gas containing 0.23 percent He^3 was condensed in a vessel of approximately 1 cm^3 capacity, which was connected to a second vessel by means of a narrow slit above the liquid level. The slit was almost gas-tight but open to the helium film. The pressure inside either of the two vessels, which were surrounded by a helium bath, could be measured against the vapor pressure of the bath by means of two differential oil manometers. In the second vessel there was a heating coil.

It is well known that in pure He^4 a fountain pressure (Δp) occurs between two vessels when a temperature difference (ΔT) is established, the contact being by way of the helium film. When ΔT is a few hundredths of a degree, Δp corresponds already to about 1 meter of liquid helium, hence the colder vessel in our arrangement will be emptied completely. With this apparatus, which is like that used by Daunt *et al.*,[1] in similar experiments, we found that the normal fountain effect can be compensated by dissolving He^3 in the colder vessel. Preliminary investigations at 1.38°K show that the "reduction" of the fountain pressure is approximately ρRTX, in which X is the He^3 concentration in the liquid in the colder vessel, the warmer vessel containing no He^3. The quantity ρRTX is the value of the osmotic pressure (P) for a dilute He^3 solution according to Van't Hoff's law. The same reduction, P, in the fountain pressure may be expected to a first approximation from the two-fluid model, if one assumes that the He^3 dissolves in the normal fluid only. According to the formulas given by De Boer and Gorter[2] (case A) the gradient of X gives rise to a gradient in x, the concentration of the normal fluid. In this picture the normal fountain effect is due to a gradient of x and this gradient is decreased by the gradient in He^3 concentration.

The values of X were derived from the measured values of the excess vapor pressure in the colder vessel due to the presence of He^3 in the vapor. This excess gives the concentration in the vapor; by measuring the height of the liquid level to obtain the volumes of liquid and vapor, we could then calculate X, the concentration in the liquid. The second column of Table I gives the values of the fountain pressure derived from the measured ΔT values using dates from Meyer and Mellink,[3] (the difference of the levels in the two vessels and the difference in vapor pressure above the two liquids can be neglected in first approximation in comparison with the fountain pressures).

Columns 4 and 5 of Table I give the calculated relative concentration c_V and c_L of He^3 in He^4 in the vapor and liquid respectively. The ratio c_V/c_L should be 300 at this temperature according to earlier measurements,[3] however, in these experiments we did not prevent the film creep circulation and did not stir the liquid as formerly, so that we are not surprised by these lower values.[4]

TABLE I. Measurements on the fountain effect.

ρRTX (mm Hg)	P (mm Hg)	v_{liq} (mm^3)	$c_V \cdot 10^2$	$c_L \cdot 10^3$	c_V/c_L
3.3	3.2	54	11	1.1	100
4.2	4.1	52	9	1.4	64
4.6	5.6	28	13	1.6	81
5.4	5.8	33	9.5	1.8	53
~8	8.5	~5	16	2.2	73

We thank Professor Gorter for very useful discussions.

Results at other temperatures will be published in Physica 's-Grav., when the accuracy of the measurements has been improved by a slight modification of the apparatus.

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On the Determination of the Relative Positron Activity of Cu^{64} in a Source of Cu^{61}

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PREVIOUS studies[1,2] of the positron spectrum of Cu^{61} have been reported under the assumption that any other activity in the source is of negligible proportions. This has been borne out through the fact that half-life measurements made at different parts of the spectrum have indicated, within experimental error, a single value of 3.33 hours, corresponding to the half-life for Cu^{61}. However, since these sources were prepared by deuteron bombardment of nickel it is quite possible that a certain amount of Cu^{64} was produced from the 1.16 percent abundant Ni^{64} isotope by a $(d,2n)$ reaction. The purpose of this discussion is to set an upper limit on the amount of positron activity which could have been attributed to Cu^{64}.

In order to determine the amount of Cu^{64} present in a given sample the decay of the Auger electrons[3] was observed by means of a lens-type magnetic spectrometer over a period of more than 24 hours following the removal of the nickel target from the cyclotron. Copper was separated by means of the electrochemical process previously described.[1]

The concentration of Auger electron energies into a small interval is advantageous for this experiment. One does not need a source of very high intensity in order to have an appreciable counting rate above background even for the very weak Cu^{64} activity. In addition the relative activity of Cu^{64} to Cu^{61} as measured by the K-capture process is larger than the corresponding ratio of positron activities. The lower intensity activity can thus be more easily observed.

If only the 3.33 hour Cu^{61} activity were present, correction of the experimentally observed data to an initial time should always lead to an Auger line whose intensity is constant. Correction of the data during the initial stages of the decay gave this result. However, as time progressed, it was found that the 3.33 hour half-life correction gave ever increasing intensities for the Auger line at the initially chosen time. The assumption of the existence of a small amount of a second activity having a half-life of 12.8 hours could however account for the decay of the sample as observed.

When corrected to the end of the $2\frac{1}{2}$ hour period of cyclotron bombardment the Auger line was found to have consisted of 99.23 percent of the 3.33 hour Cu^{61} and 0.77 percent of the 12.8 hour Cu^{64}.