ULTRAVIOLET INTERSTELLAR EXTINCTION FROM A COMPARISON OF ε PERSEI AND ζ PERSEI

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Abstract. Hall's and Stebbins and Whitford's extinction pair has been used to determine interstellar extinction in the ultraviolet. The extinction shows a feature suggestive of graphite. Previous observations of Stecher (1965) are confirmed. The results are presented in the figures.

Hall (1937) and Stebbins and Whitford (1943, 1945) used this pair of stars (ε and ζ Per) in their pioneering determination of interstellar extinction. In the current study they were selected for the same reasons, i.e., they are a bright pair of similar spectral type with about a magnitude of extinction between them and they are close together in the sky. The difference in energy distribution due to spectral type (ε is a B0.5 V and ζ is a B1 Ib) is small in the visible. Larger differences in the energy distribution due to spectral type are expected in the ultraviolet and in particular, the supergiant is expected

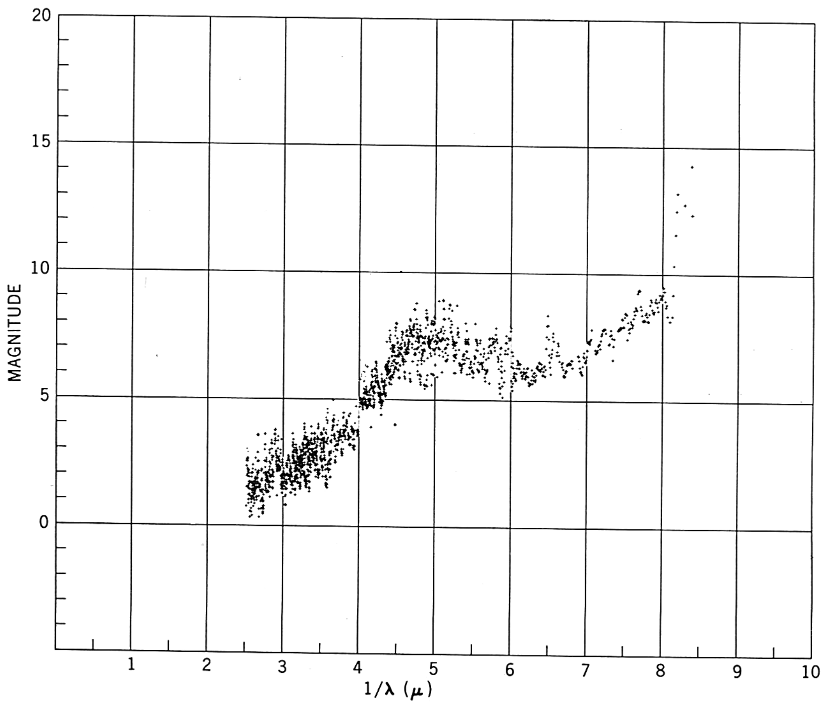

Fig. 1. Interstellar extinction in magnitudes as a function of inverse wavelength determined from ζ and ε Per scanned from short to long wavelengths. The curve is normalized to $B-V=1$ mag. and $V\sim 0$.

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to have a circumstellar shell. From previous measurements of stellar energy distributions (Stecher, 1969a), the spectral type difference was found to be small compared with effects of interstellar extinction which also becomes larger in the ultraviolet.

The observational material consists of two spectrophotometric scans of each star obtained with a 32 cm telescope which was mounted in an Aerobee rocket. The spectral resolution was 10 Å. There were three exit slits in the scanner with a photomultiplier for each covering the spectral ranges from 1100 Å to 2400 Å, 1600 Å to 3200 Å and 2400 Å to 4000 Å. The two stars were observed sequentially near the peak of the rocket flight. The absolute pointing error contributed less than 10 Å uncertainty in the wavelength. A description of the instrument appears elsewhere (Stecher, 1969b).

The data from each of the detectors for each scan of ε Per was averaged over 2 Å intervals and divided by that of ζ Per for the same interval. The magnitude was then formed and multiplied by 3.57. This is from Johnson *et al.* (1966) to normalize the observations to $B-V=1$ since the visual magnitudes are nearly equal, $V \sim 0$, and no further normalization was included. Figure 1 presents the difference in magnitudes, 3.57 (ζ Per $-$ ε Per) with the scan from short to long wavelengths. Figure 2 presents the difference in magnitudes 3.57 (ζ Per $-\varepsilon$ Per) with the scan going from long wavelengths to short wavelengths. The spectrometer was sensitive to the diffuse Lyman α line of atomic hydrogen in the geocorona. This sensitivity extends as a

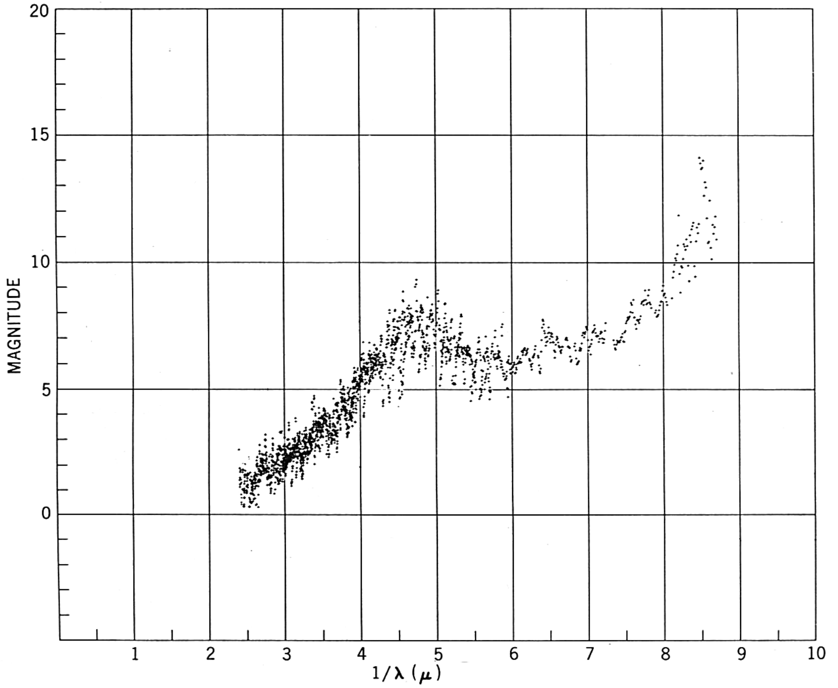

Fig. 2. Interstellar extinction in magnitudes as a function of inverse wavelength determined from ζ and ε Per scanned from long wavelength to short. The curve is normalized to $B-V=1$ mag and $V \sim 0$.

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decreasing function for about 100 Å on either side of Lyman α. If removed, the interstellar Lyman α line would give very large extinction for about 30 Å.

The large feature in the extinction curve at $4.7\mu^{-1}$ corresponds to the feature that is expected if the particles are graphite. In graphite, the feature is due to the transition to the conduction band of the π electron (Stecher and Donn, 1965; Wickramasinghe and Guillaume, 1965). While this feature could arise from other processes it would appear to be quite a remarkable coincidence if this were the case. At the shorter wavelengths graphite is insufficient to account for all the extinction. A molecular gas such as H_2^+ (Stecher and Williams, 1969) in the proper state of vibrational relaxation could make up the difference and should be considered as well as coatings. In either case, variation would probably occur at the shorter wavelengths. Some features that probably result from atomic transitions in a circumstellar shell are present. For instance, the carbon IV resonance transition at 1549 Å is quite clearly present.

Acknowledgement

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Discussion

Wickramasinghe: I merely wish to comment that this spectral feature at 2200 Å was predicted for graphite independently by Stecher and Donn, and by myself several years ago. This feature is due to a solid-state property of graphite involving a transition of π-electrons to the conduction band and it is very impressive that both the central wavelength and widths computed for this case coincide so closely with these observations. I feel this is a good indication of a graphite component of the grains.

Stecher: Yes, the signature of graphite is the bump we have here. There are of course other possibilities.

Underhill: The dip in your extinction curve for the ultraviolet falls in a region where we expect the lines in supergiants to be much stronger and entirely different in character from those of main sequence stars. What check have you that this effect is not more serious than you estimate?

Stecher: With this 10 Å resolution, one would expect to see the lines in ζ Per if the lines were that strong. This is apparently not the case.

Wilson: With regard to your suggestion that the far ultraviolet extinction may be produced by H_2^+, have you (a) estimated the density required and (b) considered whether you can maintain this density bearing in mind that the extinction process in this case destroys the carrier.

Stecher: D. A. William and I have looked into H_2^+ and can put an absolute upper limit on the density of 3×10^{-4} cm $^{-3}$. Investigation of production methods give an appreciable fraction of this. We expect to publish this in the near future.

Conti: Do the observations then represent a linear relation from 1 μ through to the UV with a hump in the UV at 2200 Å?

Stecher: The extinction is less than λ^{-1} below the hump but λ^{-1} gives a good first approximation.

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