PROBLEMS WITH THE INTERPRETATION OF THE 220 nm INTERSTELLAR FEATURE*

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Abstract. The bump in the ultraviolet part of the interstellar extinction curve provides a great challenge in the modelling of interstellar dust. Its shape can be well approximated by a classical dispersion profile with a total halfwidth of 48 nm centred at 217 nm. Apart from few slightly deviating cases the parameters of the band seem to be surprisingly constant in the solar neighbourhood.

The equivalent width $W$ of the 217 nm band shows a very tight correlation with the colour excess $E(B - V)$. Studies of correlations with the strength of diffuse interstellar bands gave no conclusive results as to the nature of the band.

The most common interpretation of the 217 nm feature as originating from small graphite grains meets several difficulties. No final decision on the carrier can be made at present.

1. Introduction

At present the interstellar extinction law is known down to about 100 nm in the ultraviolet spectral region. The following general features may be discerned:

- The linear rise in the visual region. Between 3–4 $\mu$m$^{-1}$ the curve seems to reach a saturation.
- Centred at 4.6 $\mu$m$^{-1}$ the flat part of the extinction curve is superposed by a broad 'bump'. Its properties make it very similar to an absorption band.
- The bump is followed by a flat minimum in the region 5–7 $\mu$m$^{-1}$ and by a steep rise that continues to the limits of present-day observations, e.g., to 10 $\mu$m$^{-1}$.

The interpretation of the bump has been an unresolved problem until now. The commonly accepted interpretation for the increasing extinction toward shorter wavelengths is a bimodal grain-size distribution. Larger particles with radii of 0.15 $\mu$m$^{-1}$ (amorphous silicates) cause the visual extinction, whereas smaller particles with radii of 0.05 $\mu$m$^{-1}$ produce the rise of extinction in the ultraviolet spectral region.

Following Greenberg's (1973) suggestion the extinction curve can be conveniently divided into three shares:

- a sharp rise at the shortest wavelengths produced by very small grains,
- a plateau being the flat continuation of the visual extinction curve and attributed to larger grains, and
- an absorption band at about 220 nm wavelength, whose origin is unknown up to now.

Here, the basic question arises if the total extinction curve can be represented by chemically uniform particles obeying a suited size distribution or if particles of different


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chemical composition must be necessarily taken into account. At present only the existence of silicate particles in the interstellar medium has been revealed by infrared observations. A number of absorption and emission features in the near infrared provided some hints on the chemical compositions of the grain mantles. Investigations of the 220 nm feature may give some additional insight into the nature of the particles.

2. Extraction of Parameters of the 220 nm Feature from Observations

The basic properties of the 220 nm feature which have to be extracted from the observations are the central wavelength position, the width, and the strength as well as the variations of these parameters from star to star if present.

Dorschner (1973) first pointed to the fact that the feature can be approximated by a Lorentzian profile. Savage (1975) and all subsequent investigators confirmed this finding. As a consequence of this result Gürtler et al. (1982) approximated the extinction curve in the ultraviolet spectral region by an analytical expression consisting of three terms:

- one portion arising from the Lorentzian profile, and
- two others describing the 'continuous' extinction in the ultraviolet

\[ e_{\lambda} = \alpha(\lambda^{-1} - \lambda_{0}^{-1})^{n} + \beta + \gamma \frac{\Gamma^{2}\lambda^{2}}{4\pi^{2}(\lambda^{2} - \lambda_{0}^{2})^{2} + \Gamma^{2}\lambda^{2}}. \]  

(1)

In this expression \( \lambda_{c} \) and \( \Gamma \) denote the wavelength position and the damping constant of the Lorentzian profile and \( \lambda_{0} \) is the wavelength position where the share of the continuous UV extinction starts. The free parameters \( \alpha, \beta, \gamma, \) and \( n \) were calculated from the observational data by a least-squares fit. The observed extinction \( A_{\lambda} \) and the visual extinction \( A_{\nu} \) are connected with \( e_{\lambda} \) via

\[ e_{\lambda} = 0.4(A_{\lambda} - A_{\nu}). \]  

(2)

Seaton (1979) used a similar formula in which apart from the Lorentzian profile the continuous extinction is expressed by a power series of the second order. Massa and Fitzpatrick (1986) added to Seaton's formula a third-order term.

For statistical purposes we must be interested in the strength of the extinction hump. Different investigators have defined different quantities as a measure of its strength. Widely used is the extinction at the band's centre relative to the extinction at another wavelength outside the bump.

If a dispersion profile is fitted to the observed bump by a least-squares fit the result is a central depth that is based on the profile on the whole and not on few selected points. Thus, the strength of the band derived in this way is more reliable than other measures because the description of the continuous extinction is less arbitrary. Using Equation (1) we calculated equivalent widths \( W \) for a large number of stars observed with TD-1, OAO-2, IUE, and ANS satellites (Gürtler et al., 1982; Friedemann et al., 1983; Friedemann and Röder, 1987).