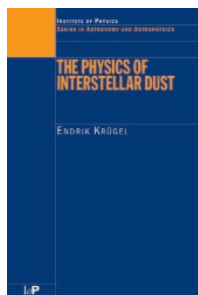


The Physics of Interstellar Dust

Endrik Krügel

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Interstellar dust grains, small solid particles in the space between stars, absorb and scatter short-wavelength UV and optical radiation and reradiate the absorbed energy as longer-wavelength infrared radiation.

Because of interstellar dust, the birth of stars is completely hidden from optical telescopes.

Endrik Krügel has converted his lecture notes about interstellar dust into a book whose provenance is clearly visible in the result. *The Physics of Interstellar Dust* can be a valuable tool to anyone interested in the subject. However, it is not organized in a way that would make it suitable as a replacement for *Light Scattering by Small Particles* (Dover, 1981) by Hendrik C. van de Hulst or the now out-of-print *Diffuse Matter in Space* (Interscience, 1968) by Lyman Spitzer. Although some introductory material describing the interstellar medium is scattered throughout the text, it is primarily concentrated near the end.

To reach a larger audience, Krügel has successfully written the book in English rather than in his native German. In an equally significant language choice, he uses Gaussian electrostatic cgs units, so the electron charge is 4.8×10^{-10} esu. Thus, this book may be used alongside Edward M. Purcell's *Electricity and Magnetism* (McGraw-Hill, 1985) and also with earlier editions of John D. Jackson's *Classical Electrodynamics* (Wiley, 1962) and George B. Rybicki and Alan P. Lightman's *Radiative Processes in Astrophysics* (Wiley, 1979).

Krügel dives right into the electrodynamics of small dielectric particles

and deftly handles this very important topic in the study of interstellar dust. He also covers thermodynamics, radiative transfer, rigid-body dynamics, semiclassical interactions between electromagnetic waves and atoms, and nuclear physics. In some ways, I view this book as containing almost all of physics applied to interstellar dust. Krügel discusses in detail temperature fluctuations in small grains and covers this topic well, which gives his book an advantage over the earlier classics by Spitzer and van de Hulst. Krügel considers a wide range of grain sizes and the importance of very small grains; he does not rely on the old idea of a "typical" interstellar grain with a $0.1\text{-}\mu$ radius.

But he doesn't give adequate coverage to other topics. For example, the "anomalous free-free emission," which is seen in cosmic microwave background maps and is an apparent excess emission at centimeter wavelengths associated with dust, is not discussed at all. Because the Wilkinson Microwave Anisotropy Probe results may not require incorporating this excess emission, not mentioning the anomalous free-free emission may have been prescient. Krügel also does not really consider the idea that dust grains have a wide variety of shapes. For very small grains, he gives the results for triaxial ellipsoids, but in general he uses only Mie scattering theory results for spheres and cylinders. He does not discuss the discrete dipole approximation that now allows one to compute the scattering and absorption properties for a range of grain shapes. Such restriction to simple grain shapes affects many parts of the book. For example, cross sections are presented as Q factors, the ratio of the actual cross section to the grain's geometric cross section. Although Q is the conventional treatment, the geometric cross section for the arbitrary grain shapes that are probable in the interstellar medium is difficult to define. I find it much more useful to abandon Q and use the cross section per unit mass instead.

In addition, the author's discussion about the microcanonical versus thermal-level populations in transiently heated, polycyclic aromatic hydrocarbon grains appears incorrect. Although the equations look correct, the results presented in figures and discussed in the text appear to reverse the differences between microcanonical and thermal-level populations. As far as I know, the differences between those two populations have not been observed in any interstellar situation, and it is very unlikely that they will

be observable in the future. As Krügel says about the precise dielectric properties of astrophysical silicates, these differences between microcanonical and thermal-level populations may be of “secondary importance in view of our general ignorance about grain properties.”

This is a substantial book aimed at the specialized study of interstellar dust. I recommend that you definitely consider using this text if you have to teach a course about interstellar dust or want to do an independent study on the topic. But read chapter 14 first for an introduction to the field and then loop back to the beginning for the details.

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