The Mid-Infrared Extinction Law and its Variation in the Coalsack Nebula

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In recent years the wavelength dependence of interstellar extinction from the ultraviolet (UV), optical, through the near- and mid-infrared (IR) has been studied extensively. Although it is well established that the UV/optical extinction law varies significantly among the different lines of sight, it is not clear how the IR extinction varies among various environments. A better understanding of the regional variation of the IR extinction law will allow a more accurate reddening correction of the photometric and spectroscopic measurements. This is also crucial for a complete description of the varying dust properties across the Milky Way.

To reveal whether and how the mid-IR extinction law relates to the interstellar environment, in this work we explore the possible variations of the mid-IR extinction within the Coalsack nebula, a nearby starless dark cloud. By using the color-excess method and taking red giants as tracers, we determine the interstellar extinction A_λ in the four *Spitzer*/IRAC bands in [3.6], [4.5], [5.8], [8.0] μm (relative to $A_{\rm K_S}$, the extinction in the *2MASS* $\rm K_S$ band) of the Coalsack nebula based on the data obtained from the *2MASS* and *Spitzer*/GLIMPSE surveys. We select five individual regions across the nebula that span a wide variety of physical conditions, ranging from diffuse, translucent to dense environments, as traced by the visual extinction, the *Spitzer*/MIPS 24 μm emission, and CO emission. We find that $A_\lambda/A_{\rm K_S}$, the mid-IR extinction relative to $A_{\rm K_S}$, decreases from diffuse to dense environments, which may be explained in terms of ineffective dust growth in dense regions. The mean extinction (relative to $A_{\rm K_S}$) is calculated for the four IRAC bands as well, which exhibits a flat mid-IR extinction law, consistent with previous determinations for other regions. The extinction in the IRAC 4.5 μm band is anomalously high, much higher than that of the other three IRAC bands. It cannot be explained in terms of the 4.27 μm absorption band of CO_2 ice and the 4.67 μm absorption band of CO ice. It may be caused by the 4.6 μm absorption feature of CO gas in the circumstellar envelopes of some red giants. The mid-IR extinction in the four IRAC bands have also been derived for four regions in the Coalsack Globule 2 which respectively exhibit strong ice absorption, moderate or weak ice absorption, and very weak or no ice absorption. The derived mid-IR extinction curves are all flat, with $A_\lambda/A_{\rm K_S}$ increasing with the decrease of the 3.1 μm H_2O ice absorption optical depth $\tau_{\rm ice}$.