Mapping dust extinction curve variation in 3D

Gregory M. Green[1], Xiangyu Zhang[1]

[1]*Max Planck Institute for Astronomy, Heidelberg, Germany*

Despite the vital importance of interstellar dust to many areas of astronomy, its composition and properties are highly uncertain. The dust extinction curve (the relation of extinction vs. wavelength) depends on both the grain-size distribution and the chemistry of the dust, and is therefore a probe of dust properties. The dust extinction curve is typically characterized by $R(V) \equiv A(V)/E(B-V)$, with higher $R(V)$ indicating a flatter extinction curve. Using low-resolution optical "XP" spectra from the *Gaia* space telescope, we have measured $R(V)$ for 130 million stars in the Milky Way and Magellanic Clouds, nearly two orders of magnitude more than have previously been available.

We present a three-dimensional map of interstellar dust $R(V)$ within a few kiloparsecs of the Sun, as well as two-dimensional maps of $R(V)$ in the Magellanic Clouds. We find relatively high $R(V)$ in the diffuse interstellar medium (ISM), with $R(V)$ first decreasing as density increases into the translucent ISM, before increasing again in the dense cores of clouds. This suggests that at intermediate densities in the ISM, accretion from the gas phase is the dominant mechanism for grain growth, while coagulation comes to dominate at higher densities. We find a strong correlation between star formation and high $R(V)$ – two possible explanations are the cycling of large grains formed by coagulation in dense molecular clouds back into the diffuse ISM, and preferential destruction of large grains by supernova shocks.

Such a large volume of precise $R(V)$ measurements will both place constraints on theories of grain chemistry and evolution, and allow the development of "next-generation" dust extinction maps that take extinction-curve variation into account, and which therefore deliver more accurate observational corrections for the effects of dust.