Scattering, Thermal Emission and Extinction: Column Density and Dust Properties
Jonathan Foster (YCAA Fellow, Yale University)

Data
Megacam on MMT J, z + UKIDSS GPS/GCS J, H, K (not shown)

Model
Hierarchical Bayesian model simultaneously infers the properties of each star and the full population.

Dust Population
\[ A'_V, R'_V \]

Using parameterized curves from Cardelli, Clayton & Mathis (1989)

Intrinsic Stellar Locus
\[ s = 1, \ldots, N_s \]

From Covey et al. (2007)

AppColors\[ s \] SpecClass\[ s \]

Results

Conclusions: We infer a correlation (\( \rho \)) between \( A_V \) and \( R_V \) in two regions of Perseus; both regions exhibit a similar trend. This trend is significant above \( A_V = 2 \) mags.

To connect this trend to physical models, we assume that for centrally condensed regions in molecular clouds, \( R_V \propto \langle v \rangle \propto n^{-1} \) \( A_V \), where \( n \) is the number density of dust grains.

The sense of the correlation is that \( R_V \) increases with increasing \( A_V \), consistent with other studies at higher column density, and well explained by grain growth in dense regions.

We denote the intrinsic stellar colour as \( v = g - i \), and denote the parameters and data for each of \( N \) stars with the label \( s \), the suite of hyper-parameters as \( H = \{\mu, \sigma^2, \alpha, \gamma\} \), and the vector of observed colours for each star as \( O^s \). The hyper-parameters describe the mean and standard deviation of the distributions in \( A'_V, R'_V \), and their covariance (\( \alpha \)). We then compute the global posterior distribution:

\[
P(\{A'_V, R'_V\}, x_s:|H, (O^s)}) \propto 
\prod_{s=1}^{N} \left[ P(O^s|x_s, A'_V, R'_V) \times P(x_s, A'_V, R'_V|H) \right] \times P(H)
\]

Support from NSF AST-0908159, AST-0407172, AST-0907903

Dust extinction is just one way to estimate the column density of a molecular cloud

Dust scattering efficiently and phase function

Absorbed
Emitted
Scattered

Scattered (aka Cloudshine)

Extinction (GNICER)

Thermal Emission (Herschel)

Dust emissivity and temperature

\[ T = 11.64 + 0.45 (\text{K}) \]

\[ A_V = 0.80 \pm 0.16 \text{ mags} \]

\[ T = 3.5 \times 10^{4} \pm 3 \times 10^{4} \text{ K} \]