Extinction Curves in the Local Group: Evidence for ISM Dust Grain Growth and Destruction

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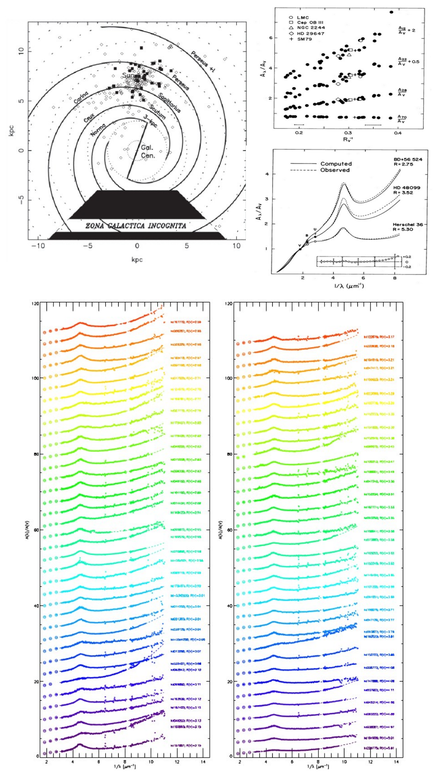
Ultraviolet through mid-infrared dust extinction curves provide an efficient probe of dust grain sizes and compositions. Combining recent new results in the SMC, M31, and M33 with existing work in the LMC and Milky Way, there is strong evidence that the large variation in extinction curves seen is likely due to dust grain growth and destruction in the ISM itself. Extinction curves in these galaxies vary significantly between having moderately rising extinction with wavelength and strong 2175 Å bumps to having no 2175 Å bump and strongly rising extinction. Correlations between UV extinction properties, gas-to-dust ratios, and carbonaceous/PAH nanograin IR emission measurements indicate that dust grain growth is happening in the ISM itself. The combined extinction behavior paints a picture of a family of curves more dependent on local conditions than on the overall galaxy properties (e.g., metallicity).

Milky Way

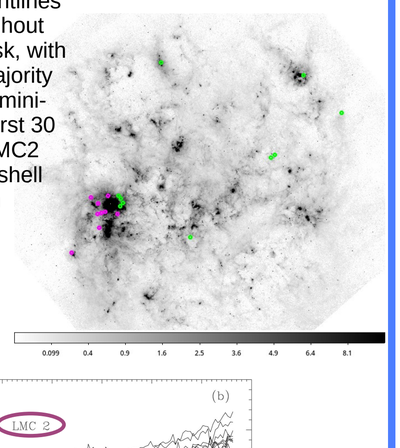
Many sightlines (400+), concentrated within ~1 kpc of Sun
Main variations correlated with R(V)

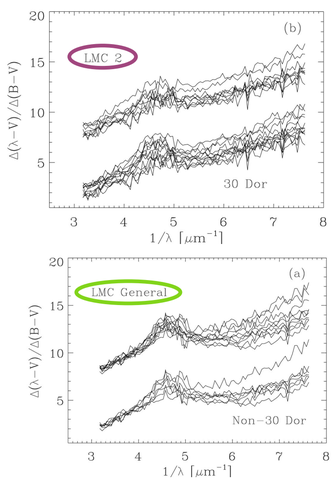


Cardelli+ 1989; Valencic+ 2004; Gordon+ 2009

Large Magellanic Cloud

19 sightlines throughout the disk, with the majority in the mini-starburst 30 Dor/LMC2 Supershell region





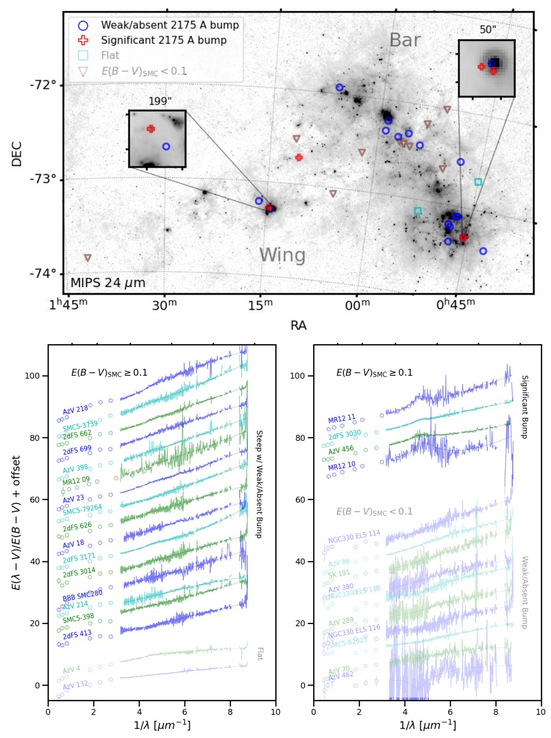
Correlation better with LMC2 supershell, than 30 Dor.

Same for LMC General, not non-30 Dor

Misselt+ 1999; Gordon+ 2003

Small Magellanic Cloud

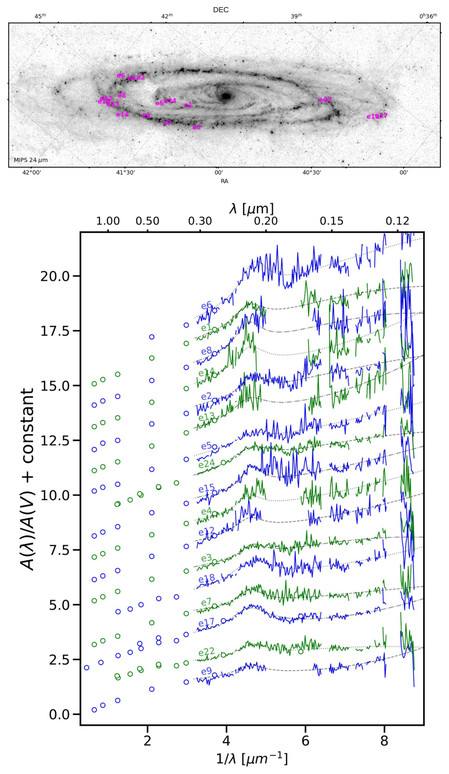
19 high quality sightlines spread throughout the Bar and Wing regions. 15 steep curves w/ no 2175 Å bump. 4 with varying 2175 Å bump strengths. (Flat and low E(B-V) suspect)



Gordon+ 2003; 2024

Andromeda/M31

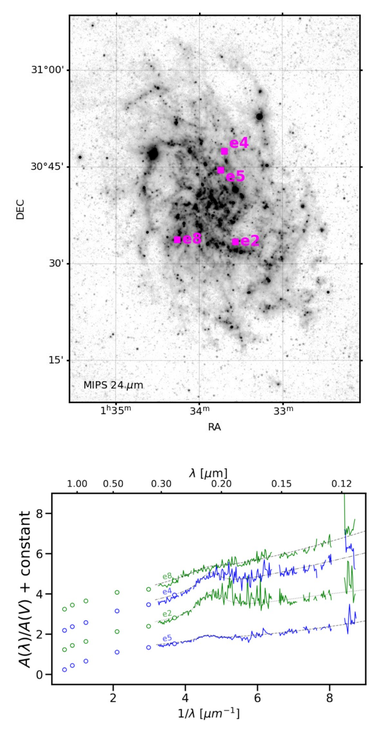
17 Sightlines spread the disk. No correlations seen with metallicity gradient.



Clayton+ 2015; 2025

Triangulum/M33

4 sightlines across the inner disk. Large variations seen, 2nd only to the variations seen in the SMC.

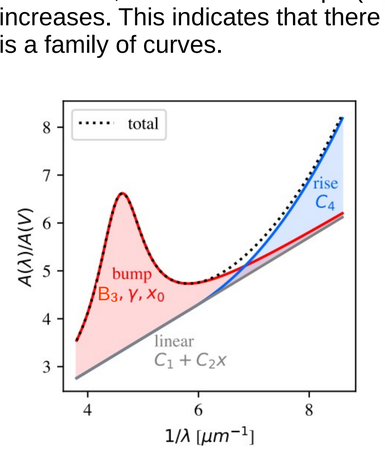


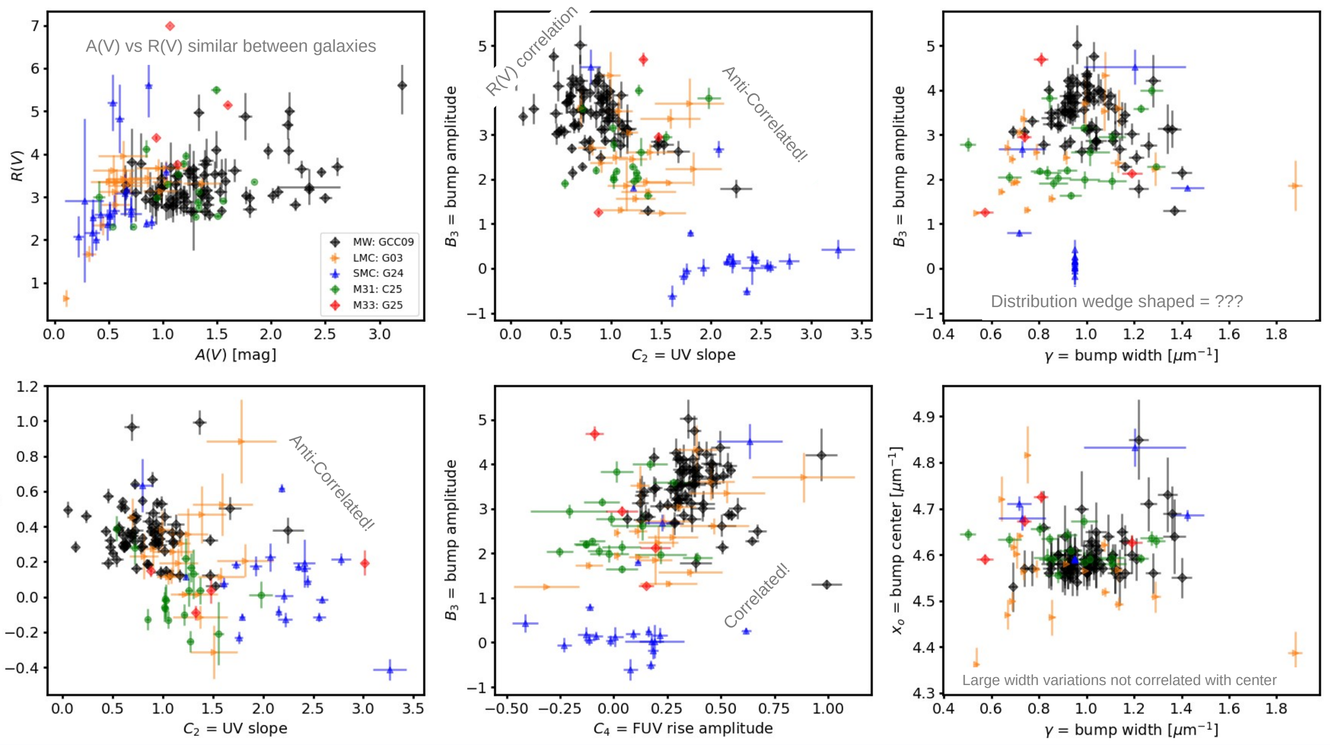
Gordon+ 2025, ApJ, submitted

Family of Curves = Order in the Chaos

Variation seen in combined Local Group sample is much larger than seen in MW. In other words, MW R(V) dependent relationship is not enough!

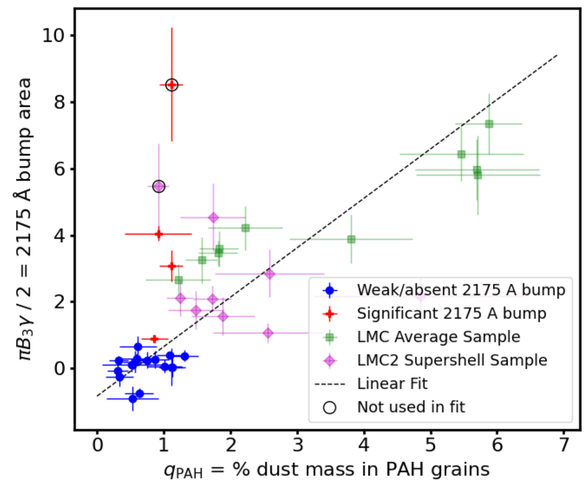
UV bump parameters correlated. For example, as the 2175 Å bump (B_3) decreases, the overall UV slope (C_2) increases. This indicates that there is a family of curves.





Bonus! 2175 Å bump vs q_{PAH}

Correlated indicating both are likely from the same material → carbonaceous/PAH nanograins



Gordon+ 2024

Variations Correlated with Gas/Dust (not metallcity)

Large variations in gas/dust seen (as probed by N(HI)/A(V), N(HI) from Lyα). MW/LMC/SMC/M33 samples have fairly uniform metallicities (MW as only within ~1 kpc of Sun), but show large gas/dust variation. M31 has a metallicity gradient, but UV shape not correlated

Gas/dust lower than expected, metals moving from gas into dust → **dust formation**.
Gas/dust higher than expected, metals moving from dust into gas → **dust destruction**.

Bump correlated with gas/dust N(HI)/A(V), not metallicity Z

Gas/Dust = dust evolution measure

dust_extinction

Python package providing a large selection of dust extinction curves including averages, parameter averages, shape models, and grain model predictions. Pip installable.

Please cite Gordon 2024, JOSS, 9(100), 7023 and original papers. Consider citing important supporting papers for some models (e.g., CCM89 and G23).