

Low-Metallicity Effects on the ISM in Galaxies

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Abstract.

The physical and chemical effects of low metallicity environments can be far-reaching in terms of molecular clouds properties, the structure of the ISM, the dust and gas properties, and the heating and cooling processes of the ISM as well as other parameters influencing star formation. The properties of the PAHs and dust are profoundly different in low-metallicity systems compared to the more metal-rich galaxies. Smaller grains dominate the spectral energy distribution, while PAHs are underabundant. The permeating, galaxy-wide hard radiation fields, in conjunction with the energetics of the supernovae shocks and winds, have assisted in modifying the dust and gas in low-metallicity environments.

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1. Introduction

The nature of the ISM in low metallicity environments was not possible to explore in depth before the advent of ISO and now Spitzer, along with ground-based submm observatories. We are fortunate to have in our local universe a wide variety of low metallicity dwarf galaxies in which to explore the properties of the dust and gas and shed some light onto conditions of primordial ISM and the evolution of the ISM. To this means we have been carrying out observations of local low metallicity galaxies at mid-infrared (MIR) to millimeter (mm) wavelengths, quantifying the dust and gas properties (Galliano *et al.* 2003; Galliano *et al.* 2005; Madden *et al.* 2005).

2. The PAH and Dust Properties

The properties of the aromatic bands, PAHs, and dust in low metallicity galaxies appear to be different from more metal rich starbursts or spiral galaxies. For example, while the PAHs at $\lambda = 6.2, 7.7, 8.6, 11.3$ and $12.6 \mu\text{m}$ are very prominent in metal-rich starbursts and dominate the MIR energy in spiral galaxies (e.g. Dale *et al.* 2000; Vogler *et al.* 2005), they are underabundant in the low metallicity environments (Madden *et al.* 2000 Houck *et al.* 2004) (Fig. 1). Is this an effect of the chemistry of the metal-poor ISM or are the PAHs destroyed in such environments? To investigate this, we use the $[\text{NeIII}]15\mu\text{m} / [\text{NeII}]12\mu\text{m}$ line ratio as an indicator of the hardness of the radiation field, and we find a strong correlation between the hardness of the global radiation field and the PAH/15 μm continuum, where the 15 μm continuum represents the smaller, warm grains (Fig. 1). This correlation may suggest that the hard radiation fields, typically present in starburst dwarf galaxies, directly impact the PAHs ability to survive, as is also expected to be the fate of PAHs within HII regions.

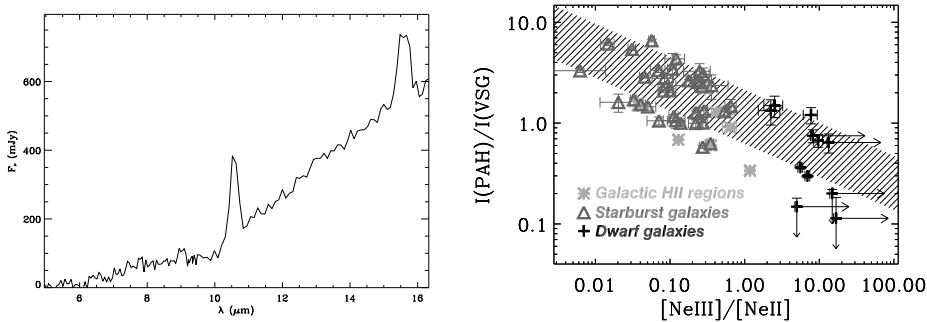


Figure 1. Global ISOCAM CVF spectra of the dwarf starburst galaxy, IIZw40 (left). While PAHs are very prominent in the MIR spectra of metal-rich starburst galaxies and disk galaxies, they are relatively underabundant in metal-poor environments. (right) The hardness of the global ISRF of galaxies and Galactic HII regions, indicated by the $[\text{NeIII}]/[\text{NeII}]$ MIR line ratios versus the PAH/15 μm dust continuum for a sample of galaxies and Galactic HII regions

Detailed modeling of the spectral energy distribution (SED) of dwarf galaxies (Galliano *et al.* 2003; Galliano *et al.* 2005), using the dust model of Désert *et al.* (1990), demonstrated dust properties dramatically different from those seen in the Galaxy. Small ($\sim 3\text{nm}$) dust grains, stochastically heated even at wavelengths as long as 100 μm , dominate the SEDs, resulting in extinction curves which resemble those seen toward several lines of sight of the Magellanic Clouds, where the slope is almost linear in $1/\lambda$ and where the 2175Å bump is relatively diminished. Additionally, the presence of a cold dust component ($T \sim 7$ to 10 K), carrying at least 50% of the dust mass of the galaxy, was invoked to account for the observed submm/mm excess (Galliano *et al.* 2005).

3. Summary

Low-metallicity systems seem to harbour non-negligible amounts of dust and the dust properties are quite different from those seen in the Galaxy. Globally, the dwarf galaxies have copious, very small MIR-emitting grain emission, and very little PAH band emission. One possible scenario that emerges, which also accounts for the presence of large quantities of cold (5 to 10 K) dust that must be resting in small dense clumps, is that the structure of the ISM of the low metallicity systems is very clumpy, allowing for large scale photoionisation of the gas in the galaxy and destruction of PAHs on galaxy-wide scales. This results in a relatively low molecular cloud filling factor.

Further progress in the detailed modeling of dust properties in galaxies will be made after the launch of Herschel in 2007, with high sensitivity and high spatial resolution FIR to submm data, allowing tighter constraints on the properties of the ISM in galaxies.

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