IRAS Spiral Galaxies of the Coldest Far-Infrared Colors

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'While IRAS data have triggered many studies on IR bright galaxies with warm far-infrared (FIR) colors of $r(60, 100) \equiv f(60\mu m)/f(100\mu m) \gtrsim 0.35$, little attention has gone to galaxies with cold FIR colors, say, $r(60, 100) \lesssim 0.25$ (roughly $T_{dust} < 26$ K), except for one or two very nearby galaxies (e.g., M31 with $r[60, 100] \approx 0.18$). Spiral galaxies with very cold global dust temperatures may be unique cases of normal galaxies caught in an extremely quiescent phase of their evolution, and are just as critical as starburst galaxies in gaining an unbiased insight into galaxy evolution processes.

We have selected a sample of 147 galaxies from among over 60,000 galaxies in IRAS FSC using $r(60, 100) < 0.25$ based on FSC flux densities. Co-added IRAS fluxes were obtained for each sample source in order to correct for lRAS beam effect. The corrected mean 1 RAS colors for this FIR-cold galaxy sample (hereafter CGS) are $r(12, 25) \approx 1.0$ and $r(60, 100) \approx 0.27$. Some statistical results can be drawn from comparisons with FIR-warm galaxies from, e.g., IRAS Bright Galaxy Catalog (hereafter BGC) with a median value of 0.5 for $r(60, 100)$: (1) As compared with the BGC, the CGS galaxies are on average about 5 time fainter in terms of the FIR luminosity but 20 to 40 times fainter in the 60pm surface brightness. (2) Most CGS galaxies are spirals of types Sab to Scd with fairly normal optical luminosities and HI masses, suggesting that they must have experienced a more vigorous star-forming period in the past and that they may not lack the raw material for active star formation. (3) For the CGS galaxies with available Hα fluxes, the FIR fluxes tend to exceed what their Hα fluxes would predict from a correlation between these two fluxes for FIR-warm galaxies. This suggests not only a very low current star-forming rate in these galaxies, but also a heating source additional to that associated with the current (massive) star formation. (4) The mean FIR-to-radio and blue-to-radio ratios for the CGS galaxies are, respectively, 2.5 and 10 times greater than those for the BGC galaxies. We conclude that these results are consistent with the two-component model with at least 60% of the FIR emission in the CGS galaxies not directly associated with the current (massive) star formation, and that the massive-star formation rate per stellar mass d reps roughly by a factor of 10 as $r(60, 100)$ decreases from 0.50 to ~ 0.27.