Excess Submm Emission In the Starburst Galaxy NGC3310

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Abstract

We present an observational study of the gas and dust properties in the starburst galaxy NGC 3310, whose bulk interstellar medium (ISM) resides in environments that mark (and bracket) the excitation extremes of the ISM conditions found in infrared luminous galaxies (Zhu et al. 2009). Our approach is to study the full neutral interstellar medium (H2, H I, and dust), constrained by fully sampled CO J=3-2 and J=1-0 observations, at a matched beam resolution of half-power beam width 15 arcsec, obtained with the James Clerk Maxwell Telescope (JCMT) and the Nobeyama 45-m telescope (Japan), combined with sensitive 850 µm and 450 µm dust emission and H I interferometric images which allow a complete view of all the neutral ISM components. One of our findings is the dust emission spectrum in NGC 3310 shows a pronounced submillimeter "excess". We tried to fit this excess by a cold dust component but very low temperatures were required (T ~ 5-11 K) with a correspondingly low gas-to-dust mass ratio of ~5-43. We furthermore show that it is not possible to maintain the large quantities of dust required at these low temperatures in this starburst galaxy. Instead, we conclude that the dust properties need to be different from Galactic dust in order to fit the submillimeter "excess". We show that the dust spectral energy distribution can be fitted by an enhanced abundance of very small grains.

NGC3310 – a Starburst Galaxy

Fig 1a: SCUBA 850 micron on HI

Fig 1b: CO(3-2) contours overlaid on a SCUBA 850 micron image. The dust emission appears to be associated with the molecular gas.

Fig 2. CO J=3-2 (red) and J=1-0 (green) profiles, the background is a SCUBA 850 grey scale map. The CO J=3-2/J=1-0 ratio ranges from 0.9 to 1.4. An LVG analysis suggests that the gas temperature is 40-60 K and gas density is ~7000 cm⁻³.

Results:

(1) The starburst galaxy NGC 3310 has high CO J=3-2/J=1-0 ratios and the average gas temperature is found to be about 50 K.

(2) NGC 3310 shows "excess" submillimeter emission which a classic two temperature model fit to its global SED would interpret as extremely cold dust with TC ~ 5-11 K, which is not consistent with the results of our CO line excitation analysis. The majority of the dust emission detected at submm wavelengths appear to be spatially associated with the molecular gas, and thus we would expect these two ISM components to have similar average temperatures.

(3) We find that a small grain population, a possible result of the extreme radiative and SNR-dominated ISM environment of this extreme system, can account for this submillimeter "excess" without postulating very cold dust temperatures in such an unlikely environment.

(4) So far submm excess emission were found in NGC 1569, NGC 3310 and NGC 4631. They represent a special type of galaxy that has dust properties different from normal spirals.

Reference:


Excess Submm Emission

SED of NGC3310

A similar case: SED of NGC 4631

Fig 4: The SED for NGC 4631 with various simple modified blackbodies fitted to the data. (a) One blackbody modified with a beta= emissivity law (fitted only to the 70-450 m data), with the best fit having a temperature of 23 ± 2 K. (b) One blackbody modified with an emissivity law with an index that was fitted to the data. The best fit has a temperature of 28 ± 2 K and a beta of 1.2 ± 0.1. (c) Two blackbodies modified with beta= emissivity laws. The best-fitting functions had temperatures of 23 ± 2 and 3.5 K (from Bendo et al. 2006).

Another case: SED of NGC 1569

Fig 5. The global SED of NGC 1569 also shows excess emission at 850 micron. When fitting with a three-temperature model, the three dust components have temperatures of 105 K (dashed line), 34.5 K (dotted line) and 7 K (dashed dotted line) (Fig 3 of Lisenfeld et al. 2002).

Fig 6. Fitting the SED with the dust model of Desert et al. (1990) which includes a very small grain (VSG) component. We found that the excess 850 micron emission could be explained by an enhanced VSG component. The resulting gas-to-dust ratio is around 300.

Fig 7. Intensity of the interstellar radiation field of NGC 3310 compared to that of the low-metallicity dwarf galaxy NGC 1569. The open symbols (triangle and square) are derived from the observed data. The filled symbols give the interpolation to the observed data points used as input in the DBP90 model. The ISRF of a normal spiral galaxy NGC 157 was also shown here for comparison. The ISRF in NGC3310 and NGC 1569 are much stronger than normal galaxies, which could be the reason for the large fraction of VSG component found in these two galaxies.