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A Gas and Dust Rich Giant Elliptical Galaxy

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Abstract. The bolometric luminosity of $L_{\rm FIR} = 2{\times}10^{12}$ $L_\odot$ makes ISOSS J 15079+7247 one of the most luminous and unusual galaxies detected by the 170 μm ISOPHOT Serendipity Survey (ISOSS). The detection of CO (1-0) emission identifies a giant elliptical galaxy at redshift $z = 0.2136$ as the counterpart of the FIR source. The derived high gas mass of $3{\times}10^{10}$ $M_\odot$ favours the picture that the dust emission is associated with this elliptical galaxy. The ultraluminous IR emission can be explained by a hidden starburst in the center of the elliptical. This is supported by the strength of non-thermal radio continuum emission. The huge dust mass of $5{\times}10^{8}$ $M_\odot$ corresponds to a visual extinction of $A_V \sim 1000$ mag, being consistent with the non-detection of any signatures of a strong starburst in ISOSS J 15079+7247 in optical spectra.

1. Introduction

The ISOPHOT Serendipity Survey (ISOSS) (Bogun et al. 1996) has observed about 2000 galaxies at 170 μm, providing a unique data base of far-infrared spectral energy distributions beyond the IRAS 100 μm limit. Stickel et al. (2000) found that *late type* galaxies generally contain a cold ($T \sim 20$ K) dust component over a wide range of infrared luminosities ($10^9 - 10^{11}$ $L_\odot$). For *early type* galaxies, however, the traditional view is that they are less dusty and less luminous in the infrared (see Knapp 1999 for a review). We summarize here a detailed study of the elliptical galaxy ISOSS J 15079+7247, detected by the ISOPHOT Serendipity Survey as an ultraluminous infrared source (Krause et al. 2003).

2. The optical counterpart of ISOSS J 15079+7247

The ISOSS source coincides in position with a compact 1.2 mm continuum source detected with the MAMBO bolometer array. The astrometric accuracy of our MAMBO observations allowed to identify an elliptical galaxy as the optical counterpart of the FIR/millimetre source (Fig. 1). Optical long slit spectroscopy revealed a pure absorption spectrum towards the nucleus. The redshift derived from the Ca H & K, G-band and Fe 5340 Å features is $z = 0.2137 \pm 0.0003$. The detection of CO(1−0) emission at the optical redshift of the elliptical galaxy strongly suggests that the molecular gas is physically associated with this galaxy. The very large molecular hydrogen mass of $M(H_2) = 2.9{\times}10^{10}$ $M_\odot$ is remarkable.

So far, significantly smaller amounts of molecular gas have been observed in ellipticals (eg. Henkel & Wiklind 1997).

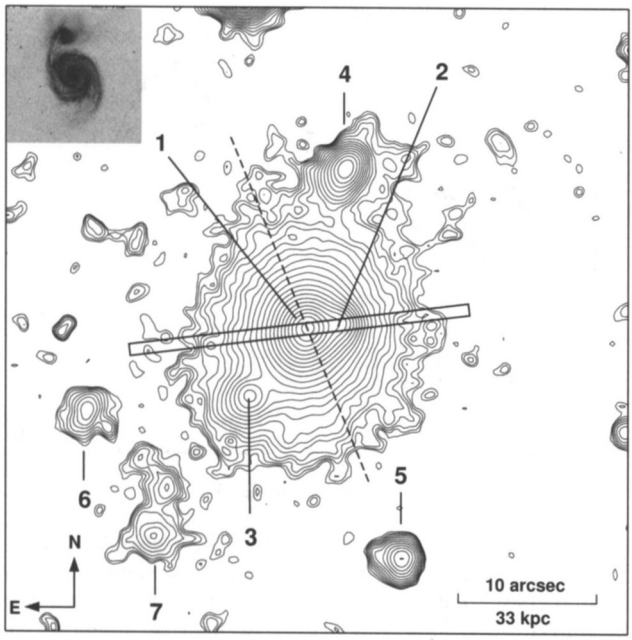

Figure 1. R-Band image of ISOSS J 15079+7247 obtained with the LAICA-camera at the Calar Alto 3.5 m telescope. The giant elliptical galaxy (1) has a close companion (2) and shows a faint tail of emission (3) towards southeast. The slit position of the spectroscopic observations is indicated (box).

3. Evidence for a starburst in the elliptical galaxy

The far-infrared to millimetre spectral energy distribution (Fig. 2) can be well fitted by an optically thick modified blackbody of 42 K, optical depth $\tau_{100\,\mu m} = 3.5$ and dust emissivity $\beta = 1.5$, yielding a dust mass of $M_d = 5.4 \times 10^8\,M_\odot$. The source was barely resolved at the VLA in the cm-continuum (Condon et al. 1998) and the deconvolved size of $\sim 4.8 \times 1.6$ kpc^2 may be considered as an upper limit for the starburst size, in agreement with our lower limit $r_b = 0.6$ kpc from the far-infrared. Assuming an average radius of 1 kpc for the nuclear starburst and spherical distribution of dust and gas, we find a total column density of $N(H) = 1.7 \times 10^{24}$ cm^{-2} towards the center. This corresponds to a visual extinction of $A_V \sim 1000$ mag and explains the absence of any optical emission lines towards the center of the elliptical, which is very unusal for ULIRGs (Veilleux et al. 1999). ULIRGs normally show a much more disturbed morphology and emission line spectra in their centers. ISOSS J 15080+7248 may be an elliptical galaxy merging with a gas rich spiral inducing a powerful starburst in the center of the elliptical. The large amount of molecular gas and dust detected in the elliptical

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galaxy ISOSS J 15079+7247 suggests an alternative explanation of the nature of several other high-redshifted submm-galaxies.

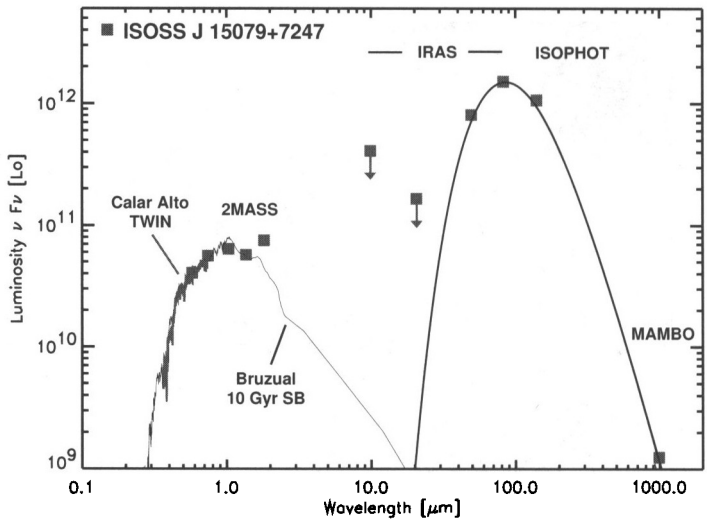

Figure 2. Rest frame spectral energy distribution of ISOSS J 15079+7247. The FIR dust emission can be well characterized by an optically thick modified blackbody (solid line). The optical and near-infrared emission can be fitted by a 10 Gyr old starburst following Bruzual & Charlot 1995.

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