VIOLENT MOTIONS IN STARBURST GALAXIES: THE OH MEGAMASER IN IRAS 10039-3338.

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In a comparative study, optical and radio spectra are presented in order to further investigate violent turbulent motions in starburst galaxies. Emission-line, HI and OH profiles of IRAS 10039-3338 exhibit signs of a highly perturbed far-infrared galaxy. Remarkably narrow and distinct OH components are shown in the megamaser spectra. A molecular mass of $10^{10} M_{\odot}$ is deduced from CO observations. The presence of comparable numbers of blue and red-shifted components is apparently not in favor of an outflow interpretation.

Optical results

We took blue and red spectra respectively at ESO and Cerro-Tololo. These data showing deep Balmer absorptions from underlying stellar continua and prominent emission lines of Ha, Hb, N II and S II have been used to measure the redshift of IRAS 10039-3338 accurately (procedure described in Proust et al.1988). The lines were fitted with a third-order polynomial; the average r.m.s. of the ESO calibration was 0.25, and the resolution as measured from the FWHM of a Gaussian fit to the He-Ar lines was 5Å.

Radio results

We obtained the HI spectrum of IRAS 10039-3338 at the Nançay telescope. Most, if not all, luminous far-infrared galaxies and in particular the prototypical ones, exhibit HI spectra which are asymmetric and/or present emission and absorption, as opposed to the regular double-peaked spectra of normal spiral galaxies. Likewise the HI spectrum shows asymmetry with respect to the peak velocity of 10238 km s^{-1}, a pronounced red wing and a possible absorption around 10124 km s^{-1}. Another characteristic of these galaxies is their broad spectra and their relatively high HI mass; at noise level, IRAS 10039-3338 exhibits a width greater than 500 km s^{-1}. The measured area under the profile corresponds 2.5 Jy kms^{-1} which amounts to an HI mass of 1.2 10^{10} Mo .

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The CO spectrum has been obtained in 2 hours with the SEST telescope; the main-beam integrated emission is 3.1 K km/s. With a conversion ratio $N(H_2)/I(CO)$ of 2.3 $10^{20} cm^{-2}$ (K km/s)$^{-1}$, we find a molecular mass of 10^{10} M_o. The central CO velocity is 10 260km/s, which corresponds to the optical and HI velocities. The OH emission seems to come from a different region.

Discussion

The radio and optical observational results show clearly that IRAS 10039-3338 is a highly perturbed galaxy. The megamaser phenomenon tends to exhibit signs of activity contained in AGNs, Seyfert II and starburst nuclei, all related to luminous far-infrared galaxies. The complex aspect of the nucleus, the multi-component OH profile and the asymmetry of the HI profile are reminiscent of strong interaction with a substantially disturbed velocity field. The difference in peak velocities between HI and OH reflects the highly turbulent motion in the object. However, the balanced number of blue and red-shifted velocity components represents no evidence for an outflowing wind being the source of the motions. These could come from violent tidal perturbations accompanying a merger. Indeed, the CCD image shows a curved southwest extension which may correspond to a tidal tail.

The observed proportionality between L(OH) and the square of L(IR) strongly suggests that infrared photons radiated by grains within the nuclear dust are mainly responsible for the inversion of the OH molecules (Baan et al., 1987; Bottinelli et al.,1987). A comprehensive study of the proportionality relation is given by Martin et al.(1989). Moreover Henkel et al. (1987) and Henkel and Wilson (1990) point out that because of the large linewidth generally encountered, line overlap effects might be important. In particular, overlap between far-infrared lines within the same hyperfine doublets lead to linewidths between 3 and 13 Km s^{-1}. Burdyuzha and Vikunov (1990) find a velocity range between 0.7 and 5 km/s. As compared to the collisional excitation-by-neutrals-and-charged-particles hypothesis, the radiative excitation hypothesis seems satisfactory. However, it remains to be proven that there is enough line-overlap in the case of multiple velocity components.

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