Sensitive VLBI Observations of the ULIRG IRAS 17208-0014

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ABSTRACT

We present phase-referenced VLBI results on the radio continuum of, and the 21 cm H I absorption toward, the Ultra-Luminous Infrared Galaxy (ULIRG) IRAS 17208-0014 (cz=12790 km s^{-1}). The observations were carried out at 1362 MHz using the VLBA, including the phased VLA as an element. The high-resolution radio continuum images reveal a nuclear starburst region in this galaxy, which is composed of diffuse emission approximately 670 x 340 pc on the plane of the sky, and a number of compact sources. These sources are most likely to be clustered supernova remnants and/or luminous radio supernovae. The derived massive star formation rate is ~84 $M_\odot$ yr^{-1}, and the supernova rate is ~4 yr^{-1}. H I absorption is detected in multiple components with optical depths ranging between 0.3 and 2.5, and velocity widths between 58 and 232 km s^{-1}. The H I absorption shows a strong velocity gradient of 453 km s^{-1} across 0.36 arcsec (274 pc). Assuming Keplerian motion, the enclosed dynamical mass is about 2.3 x 10^9 (sin^{-2} i) $M_\odot$, comparable to the enclosed dynamical mass estimated from CO observations.

INTRODUCTION

At luminosities above 10^{11} $L_\odot$, infrared galaxies become the most frequently occurring extragalactic objects in the local universe (z < 0.3) (Sanders & Mirabel 1996). Galaxies at the highest infrared luminosities (10^{12} $L_\odot$), known as ULIRGs, are believed to be advanced merger systems. The intense infrared emission originates from dust grains heated by a central power source or sources (AGN or starburst, or a combination of both).

IRAS 17208-0014, with L_{IR}=2.3x10^{12} $L_\odot$, is a nearby ULIRG (z=0.0426). Infrared observations suggest that this galaxy represents the extreme of starburst dominated sources of this type (Soifer et al. 2000).

MERLIN 1662 MHz radio continuum observation at 0.3 arcsec resolution revealed the existence of an unresolved component on the longest baselines, with a constant visibility amplitude of ~35 mJy (Martin et al. 1989) .

Strong OH maser emission (L_{OH}= 10^3 $L_\odot$), a very wide CO emission and H I absorption lines are associated with this galaxy (Martin et al. 1989; Diamond et al. 1994; Downes & Solomon 1998).

H I absorption optical-depth spectra

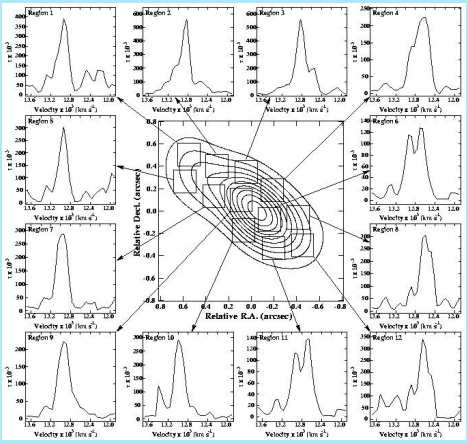


Figure 2: Hanning-smoothed H I optical-depth spectra obtained at various locations against the background continuum source IRAS 17208-0014. The restoring beam size is 0.55 x 0.35 arcsec at position angle 34^o. The contour levels of the continuum image are at 3, 6, …, and 30 mJy beam^{-1}. A Gaussian taper falling to 30% at 0.5 Mλ was applied.

Continuum image of IRAS 17208-0014

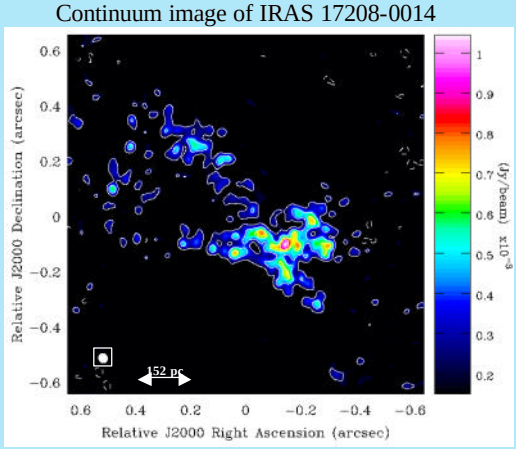


Figure 1: Continuum image of the central region in IRAS 17208-0014 at 1362 MHz. The restoring beam size is 36 x 33 mas at P.A. 25^o. The contour levels are at –3, 3, 6, 9, 12 times 70 μJy beam^{-1} (1σ). A Gaussian taper falling to 30% at 6 Mλ in the u-direction and 4.5 Mλ in v-direction was applied.

RESULTS and DISCUSSION

1. *The continuum*

- The high-resolution continuum image at 1362 MHz (Fig. 1) reveals the details of the previously undetected nuclear region of this galaxy.
- The total VLBI flux density is 52 mJy, and represents only half of the total flux seen with the VLA at a lower resolution, suggesting the existence of diffuse emission not detected by our VLBI array.
- The radio-FIR correlation suggests that this galaxy is dominated by a starburst.
- We distinguish 25 compact sources with flux densities > 5σ (350 μJy beam^{-1}) and an average linear dimension of ~45 pc. Their brightness temperatures range over (2.2-6.6) x 10^5 K, indicating the emission is non-thermal and not from H II regions.
- The compact sources are more likely clustered luminous RSNe and SNRs. However, we cannot rule out the possibility that each of these compact sources is mainly powered by an individual bright RSNe nested in a region that contains faded SNRs.
- Both the FIR luminosity and the radio continuum flux imply a massive SFR of ~84 $M_\odot$ yr^{-1} and a supernova rate of 4 yr^{-1}.
- Our results suggest that there is no radio-loud AGN in the nuclear region of IRAS 17208-0014.

2. *The* H I *absorption*

- The 21 cm H I absorption was only detected on the shortest baselines to the phased VLA, primarily on Y27-Pie Town.
- The H I absorption (Figs. 2 & 3) is composed of five main features. Three of them are wide ($\Delta V_{50\%}$=174-232 km s^{-1}) with τ<1, and the other two are relatively narrow ($\Delta V_{50\%}$=58 km s^{-1}) with τ>1. Their column densities are on the order of 10^{20} T_s (cm^{-2} K).
- The PV diagram at position angle 120^o (Fig. 4) shows a strong velocity gradient of 453 km s^{-1} over 0.36. Assuming Keplerian motion, the enclosed dynamical mass is 2.3 x 10^9 (sin^{-2} i) $M_\odot$, comparable to the enclosed dynamical mass estimated from CO (1-0) observations (Downes & Solomon).
- The strong velocity gradient of the H I absorption suggests a rapidly rotating disk in the nuclear region of this galaxy, while the multiple H I absorption features indicate the existence of several discrete clouds in this disk.

Optical-depth channel images

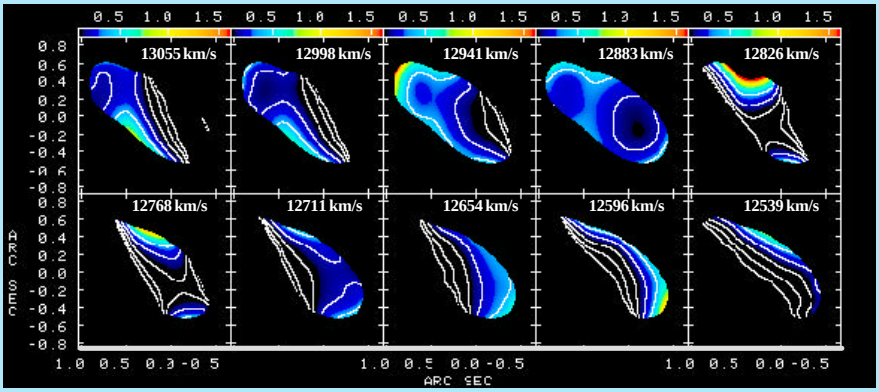


Figure 3: H I optical-depth channel images toward IRAS 17208-0014 in the velocity range 13055-12539 km s^{-1}. The restoring beam size is 0.55 x 0.35 at position angle 34^o. The velocity resolution is 58 km s^{-1}.The contour levels are at 0.1, 0.2, 0.4, 0.8, and 1.6.

H I absorption velocity field

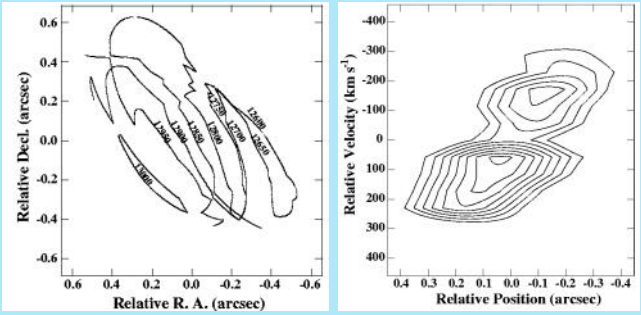
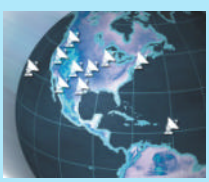


Figure 4: *Left:* Velocity contours of the H I 21 cm absorption in steps of 50 km s^{-1}. The restoring beam size is 0.55 x 0.35 at position angle 34^o.

Right: H I PV plot at position angle 120^o. The contour levels are at –1.5, –2, …, and –6 mJy beam^{-1}.



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