Observations of IRAS F10214+4724 at the Nobeyama Millimeter Array

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We have made CO(3-2) aperture synthesis observations of the z=2.286 IRAS source F10214+4724.

1. Introduction

F10214+4724 is an IRAS source at z=2.286 with $L_{FIR} \sim 10^{14} L_\odot$ (ref. *3*). The CO(3-2) emission was detected at the NRAO 12-m telescope (ref. *1*), and its molecular gas mass was estimated to be (1-3) $\times 10^{11} M_\odot$ (ref. 6). This object is unique and important because it is the first high-z object from which molecular line emission is detected and it enables us to investigate molecular gas content, star forming material, at an early stage of galactic evolution (the look back time is 17% of the present age of the universe. H_0=100 h km/s/Mpc and q_0 = 0.5 are assumed).

If IRAS F10214+4724 is a primeval galaxy at the formation process, it is possible the gas has not been collapsed yet to the galactic scale. On the other hand, it is also possible IRAS F10214+4724 is a merging or interacting system like the most of ultra-luminous infrared galaxies (ref. *5*). However, since the first detection was made with a medium size single-dish telescope (beam size ≈ 60" = 240 h^{-1} kpc), the precise position, extent, and distribution of the molecular gas had not been determined. The aim of our aperture synthesis observations is therefore to determine position and distribution of molecular gas.

2. Observations

Telescope : Nobeyama Millimeter Array (mm-wave interferometer with five 10-m antennas)

Date : January 21-25 and February 19-24, 1992, Array configuration : D, Integration : 32 hours

Line : CO(3-2), Center Frequency : 105.2 GHz, Bandwidth : 320 MHz = 910km/s, 1024ch

Phase tracking center : 10h21m31.14s, +47°24'22.9" (1950) , Calibrator : 0923+392 (4.5 Jy)

Field of view : 70"=280h^{-1}kpc (HPBW), Resolution : 8.9"× 6.0"=36× 24h^{-1}kpc (HPBW), PA=132°

3. Results and Discussion

Our main results are, (1)a compact emission is detected at the position of optical object (Fig.1, here we refer it as the *nuclear compact component*), (2)the nuclear compact component has about half the line width than previously reported as the first detection (Fig.2), (3)the beam deconvolved size, which gives an estimate of an upper limit size, of the nuclear compact component is about 3"=12 h^{-1} kpc, and (4)velocity gradient of the molecular gas was not detected.

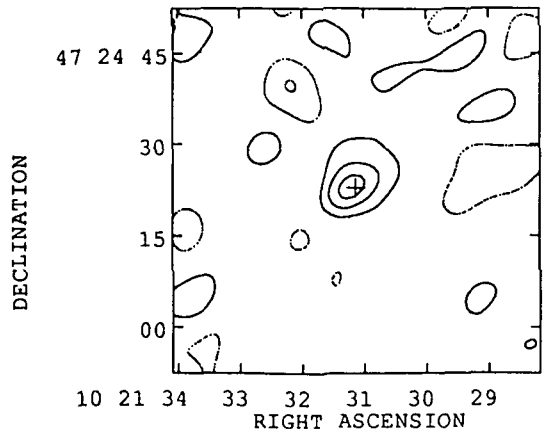

Fig.1 CO(3-2) map of IRAS F10214+4724 (ref. *4*)

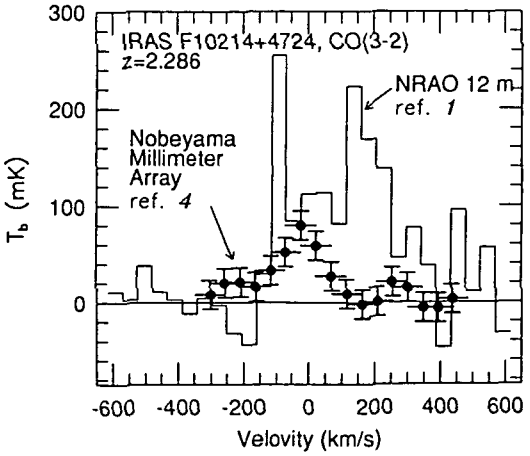

Fig.2 CO(3-2) spectrum (ref. *4*).

	our results	previous reports
position (1950)	10h21m31.2s,+47°24'23" (±1"),	10h21m31.12s,+47°24'23.9" (±0.5"), (ref.*3*)
CO(3-2) flux	7.5±1.9 Jy km/s	26 Jy km/s (ref.*1*)
line width	200 km/s	365 km/s (ref.*1*)
size	< 3"± 0.5" (CO(3-2))	4" (ref.*3*, optical)
$L_{CO(3-2)}$	$6.3 \times 10^{7}\ h^{-2}\ L_{\odot}$	
$M(H_2)$	$(2 - 11) \times 10^{11}\ h^{-2}\ M_{\odot}$ (the assumptions to derive the mass is discussed in ref. *4*)	
$\Sigma(H_2)$	$> (2 - 10) \times 10^{3}\ M_{\odot}\ /pc^{2}$	

Our observations served the following clues to the nature of IRAS F 10214+4724.

(1) A compact emission, the nuclear compact component, is associated to the optical object ('object F' in ref.*3*); thus the identification is confirmed.

(2) The nuclear compact component has already collapsed to the typical size of galaxies and its surface density of molecular gas is comparable to that of infrared luminous galaxies.

(3) From comparison of spectra obtained at the Nobeyama Millimeter Array and the NRAO 12-m telescope, it is suggested that there is some object which cannot be detected by interferometric high-resolution imaging, this suggest the extra object is extended or consists of a number of sub-components. It is necessary to confirm and determine the full linewidth with a medium size, i.e. field of view ~ 1', filled aperture telescope.

(4) If IRAS F 10214+4724 consists of a number of components, and taking account of the high concentration of molecular gas in the nuclear compact component, it is suggested that IRAS F 10214+4724 is a merging or interacting system.

(5) It is possible that intense star formation to occur because of the high concentration of molecular gas in the nuclear compact component. From the view point of infrared colors, however, an AGN is preferred as its dominant source of the huge luminosity of IRAS F 10214+4724 (see ref. *4*).

4. Future prospects

There are several bright sub-mm lines redshifted into millimeter atmospheric windows (Fig. 3).

CO(4-3), CI($^3P_1$-$^3P_0$) in 150GHz window

CO(7-6),(6-5), CI($^3P_2$-$^3P_1$) in 230GHz window

Observations of these lines and dust emission will determine physical condition of ISM in IRAS F102 14+4724. If there is a new class of objects similar to IRAS F10214+4724, or large mm-wave interferometers now in planning, such as the Large Millimeter Array (LMA) and the Millimeter Array (MMA), are constructed, it will be an interesting to prove the ISM in high-z objects with molecular and atomic lines. Such observations will affect the studies of formation and evolution of galaxies.

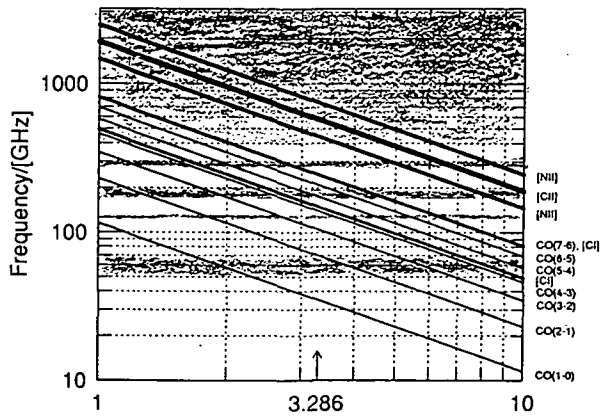

Fig. 3

5. References

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