SLOW ROTATION OF GAS IN THE HALOS OF EDGE-ON GALAXIES M82 AND NGC 4631

Y. SOFUE[1], N. NAKAI[2], T. HANDA[1],

G. GOLLA[3], H.-P. REUTER[3], R. WIELEBINSKI[3]
1. Institute of Astronomy, Univ. of Tokyo, Tokyo 181, Japan
2. Nobeyama Radio Observatory, Nagano 384-13, Japan
3. MPIfR, Auf dem Hügel 69, Bonn 1,FRG

ABSTRACT: The rotation velocity of molecular gas in the halos of M82 and NGC4631 decreases with the height from the galactic plane. The slower rotation of halo gas can be explained if the gas is supplied from the central region of the galaxies due to some ejection.

1. INTRODUCTION

Molecular gas observations in the CO line emission of the edge-on galaxies M82 and NGC 4631 have been extensively made with the IRAM 30-m telescope and the Nobeyama 45-m telescope (Loiseau et al 1990; Sofue et al 1990). The galaxies are rich in molecular gas, and the high angular resolution maps in the CO line emission have given opportunity to study the kinematics of the halo gas. Observations of the ^{12}CO($J = 2 - 1$) line of M82 and NGC 4631 were made from 1987 through 1990 using the 30-m telescope of IRAM. The antenna had a HPBW of 13″ at 230 GHz.

2. MOLECULAR GAS OUT OF THE PLANE

(a) M82: Obtained ^{12}CO($J = 2 - 1$) and ^{12}CO($J = 1 - 0$) line spectra shows that there exists a shift of $V_{\rm LSR}$ at high latitudes: $V_{\rm LSR}$ varies with the distance from the galactic plane. Position-velocity diagrams at different latitudes for M82 show clearly that the rotation is slower in the halo than in the disk. The rotation velocity of the disk is about 100 km s^{-1} , while the rotation at $Y = 300$ pc is about a half, ~ 50 km s^{-1} . Fig. 1 shows the rotation curves at different heights in M82.

(b) NGC 4631: Fig. 2 shows ^{12}CO($J = 2 - 1$) spectra for NGC 4631. Note that $V_{\rm LSR}$ at $X = -42''$ varies with the distance from the plane. Data are not good enough to make position-velocity diagrams. However, from the shift of $V_{\rm LSR}$ with latitude, we can see that the rotation velocity is slower in the halo region than in the disk:.The maximum rotation in the disk is about 150 km s^{-1} , while it decreases to 70–80 km s^{-1} at $Y = -24''$ (–600 pc).

H. Bloemen (ed.), The Interstellar Disk-Halo Connection in Galaxies, 307–308.

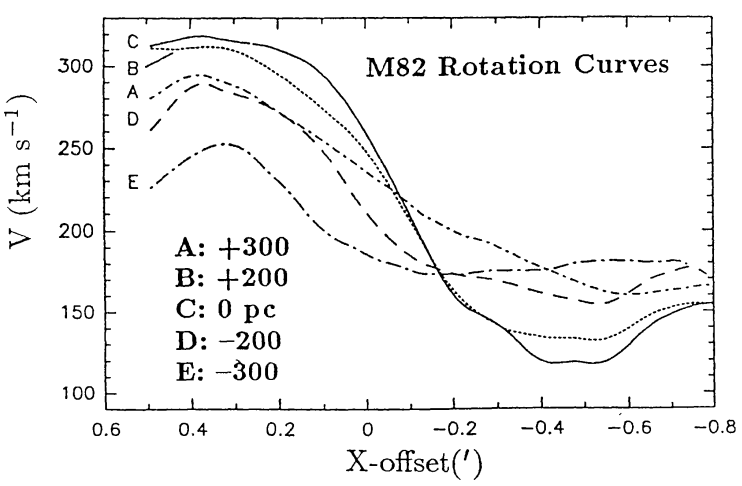

Fig. 1 Rotation curves of M82.

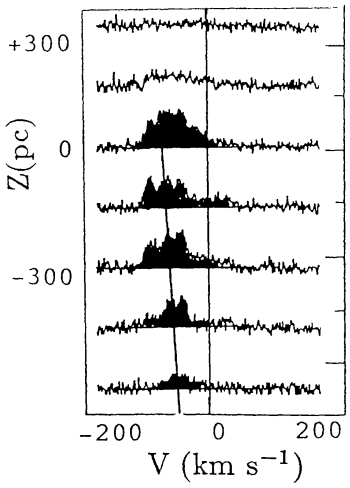

Fig. 2 NGC 4631, $X = -1$ kpc.

3. DISCUSSION

In the two edge-on galaxies, M82 and NGC 4631, the rotation velocity of molecular gas in the halo at the height of a few hundred pc is slower than that in the disk. The following two possibilities can be considered to explain the slower rotation in the halo:

(1) Outflow model: The halo molecular gas has been supplied from the central region of the galaxy. Because of the transfer of smaller angular momentum from the central region, the gas attains a slower rotation compared to the disk when the gas reached at larger radius. In this case the gas flow should be not only perpendicular to the disk but also radial.

(2) Primordial halo model: The molecular gas observed in the halo is supplied from the galactic plane driven by activities like, SN explosions, magnetic inflations, etc.. If there exists a gaseous halo which is the remnant of a primordially slowly rotating halo, the gas supplied from the disk will suffer from braking by the existing halo gas. It is unlikely, however, that the observed molecular gas itself is the primordial halo gas because of its heavy-element content.

In the present case of M82 and NGC 4631, the former model seems more plausible, becasue both the galaxies show activity in the central molecular disk with active star formation. Namely, M82 is the well-known starburst galaxy with an intense outflow, and NGC 4631 is known by its high-luminosity radio continuum disk and a large nonthermal halo with magnetic field.

references

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