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# Hot gas in the center of the Seyfert galaxy NGC 3079

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**Abstract.** The nearby (d = 19.7 Mpc) Seyfert galaxy NGC 3079 exhibits a prominent bubble emerging from the nucleus. In order to investigate the nuclear power source, we carried out ammonia observations toward the center of NGC 3079 with the Tsukuba 32-m telescope and the JVLA. The $NH_3$ $(J, K) = (1, 1)$ through $(6, 6)$ lines were detected in absorption at the center of NGC 3079 with the JVLA, although the profile of $NH_3$ $(3, 3)$ was in emission in contrast to the other transitions. All ammonia absorption lines have two distinct velocity components: one is at the systemic velocity ($V_{\rm sys} \sim 1116$ km s$^{-1}$) and the other is blueshifted ($V_{\rm sys} \sim 1020$ km s$^{-1}$), and both components are aligned along the nuclear jets. The blueshifted $NH_3$ $(3, 3)$ emission can be regarded as ammonia masers associated with shocks by strong winds probably from newly formed massive stars or supernova explosions in the nuclear megamaser disk. The derived rotational temperature, $T_{\rm rot} = 120 \pm 12$ K for the systemic component and $T_{\rm rot} = 157 \pm 19$ K for the blueshifted component, and fractional abundance of $NH_3$ relative to molecular hydrogen $H_2$ are higher than those in other galaxies reported. The high temperature environment at the center may be mainly attributed to heating by the nuclear jets.

**Keywords.** galaxies: individual (NGC 3079), galaxies: ISM, radio lines: galaxies, ISM: molecules

## 1. Introduction

Galactic winds influence galaxy evolution because they play an important role in the cycle of material transport in the galaxy. The winds are driven by supernovae and/or AGNs. One of the clearest examples of a superwind is the prominent bubble emerging from the nucleus of the Seyfert galaxy NGC 3079 (figure 1(a)) at a distance of 19.7 Mpc. Investigations of the physical properties of molecular gas around the nucleus are helpful to understand the nuclear power source. Ammonia ($NH_3$) is a useful thermometer (e.g., Walmsley & Ungerechts(1983)) for relatively dense molecular gas. The rotational temperature can be derived from the ratio of column densities of the metastable $[J, K(= J)]$ levels. The adjacent inversion lines in frequency allow us to measure the lines simultaneously with the same telescope and receiver and thus to evaluate the line ratios accurately owing to the similar beam sizes, same telescope pointing and atmospheric conditions.

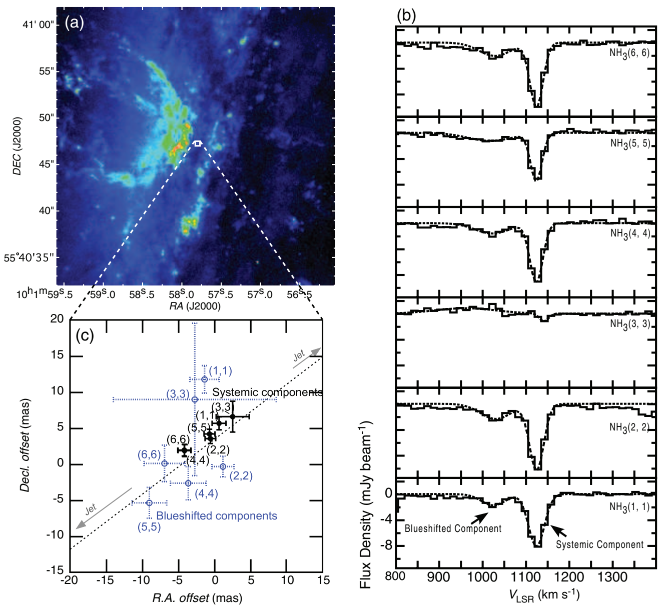


**Figure 1.** **(a)** *HST* WFPC2 images of NGC 3079. **(b)** The spectra of $NH_3(J, K) = (1, 1)$ through $(6, 6)$ lines at the center of NGC 3079. **(c)** Enlargement of the central region in (a). Filled and open circles indicate the peak positions of $NH_3(1, 1)$–$(6, 6)$ for the systemic and blueshifted components.

## 2. Ammonia in the center of NGC 3079

Observations of ammonia toward the center of NGC 3079 were made with the Tsukuba 32-m telescope of the Geospatial Information Authority of Japan and the A-configuration of the Karl G. Jansky Very Large Array (JVLA). The six ammonia inversion lines, $NH_3(1, 1)$ through $(6, 6)$, with two distinct velocity components of the systemic velocity ($V_{\rm LSR} \sim 1116$ km s$^{-1}$) and blueshifted ($V_{\rm LSR} \sim 1020$ km s$^{-1}$) were detected in absorption against the continuum source, although the profile of the $NH_3(3, 3)$ was in emission (figure 1(b)). The existence of $H_2O$ maser formed by local shock related to star formation (Yamauchi *et al.*2004) suggests that the emission features of $NH_3(3, 3)$ are caused by the $NH_3(3, 3)$ maser. Using para-$NH_3(1, 1), (2, 2), (4, 4)$ and $(5, 5)$ lines with the JVLA, we derived the rotational temperature of $120 \pm 12$ K and $157 \pm 19$ K in the systemic and blueshifted components, respectively. Combined column densities of the measured lines plus the extrapolated $(0, 0)$ column and the fractional abundance of $NH_3$ relative to $H_2$ ($= 6.8 \times 10^{23}$ cm$^{-2}$: Koda *et al.*2002) become $(8.85 \pm 0.70) \times 10^{16}$ cm$^{-2}$ and $1.3 \times 10^{-7}$ for the systemic component, and $(4.47 \pm 0.78) \times 10^{16}$ cm$^{-2}$ and $6.5 \times 10^{-8}$ for blueshifted. All ammonia absorption lines align along the nuclear jet (figure 1(c)). The high temperature and fractional abundance of $NH_3$ can be attributed to the jet (Miyamoto *et al.*2015).

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