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XDR Chemistry in the Circumnuclear Disk of NGC 1068

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Abstract. We have studied the feedback influence that the central engine of the Seyfert 2 galaxy NGC 1068 may have on the chemistry of the 200 pc circumnuclear gas disk (CND). With this purpose, we have conducted a multi-species/multi-transition survey of molecular gas in the CND of NGC 1068 using the IRAM 30m telescope. Abundances of several molecular species have been estimated, including HCN, CN, CS, HCO^+, SiO and HOC^+. We report on the detection of significant SiO emission in this galaxy, as well as on *the first extra-galactic detection of the active radical* HOC^+. We conclude that the chemistry of the molecular gas reservoir in the CND can be best explained in the framework of X-ray Dominated Region (XDR) models.

Increasing observational evidence suggests that nuclear winds and X-rays may have a disruptive influence on the molecular gas in the vicinity of the supermassive Black Holes of AGN. XDR could be the dominant sources of emission for molecular gas in the CND of active galaxies. The first evidence of AGN-driven chemistry was provided by the large HCN/CO abundance ratio ~ 0.01 found by Sternberg, Genzel & Tacconi (1994) in the CND of NGC 1068. Different explanations have been advanced to account for this anomalous HCN chemistry. Selective depletion of gas-phase oxygen in the dense molecular clouds would explain the measured high HCN abundance (Sternberg et al. 1994). Alternatively, an increased X-ray ionization of molecular clouds near the AGN could enhance the abundance of HCN (Lepp & Dalgarno 1996).

While the aforementioned scenarios intend to reproduce the measured enhancement of HCN in NGC 1068, their predictions about the abundances of some molecular species differ significantly. In order to constrain observationally the choice of the optimum scenario, we have obtained new IRAM 30m spectra towards the CND for some of these molecular species. The list includes SiO, HCO^+, $H^{13}CO^+$, HOC^+ and CN (Usero et al. 2003). We have run LVG models based on the results of these observations and on previously published data (CO: Schinnerer et al. 2000; HCN and CS: Tacconi et al. 1994, 1997). We have estimated that abundances of oxygen-bearing species are similar to those of non-oxygenated ones (e.g.: we measure $HCN/HCO^+ \sim 1$). These results are at odds with the predictions of oxygen depletion models. On the contrary, the overall abundances fit the predictions of XDR chemistry schemes (Lepp & Dalgarno 1996).

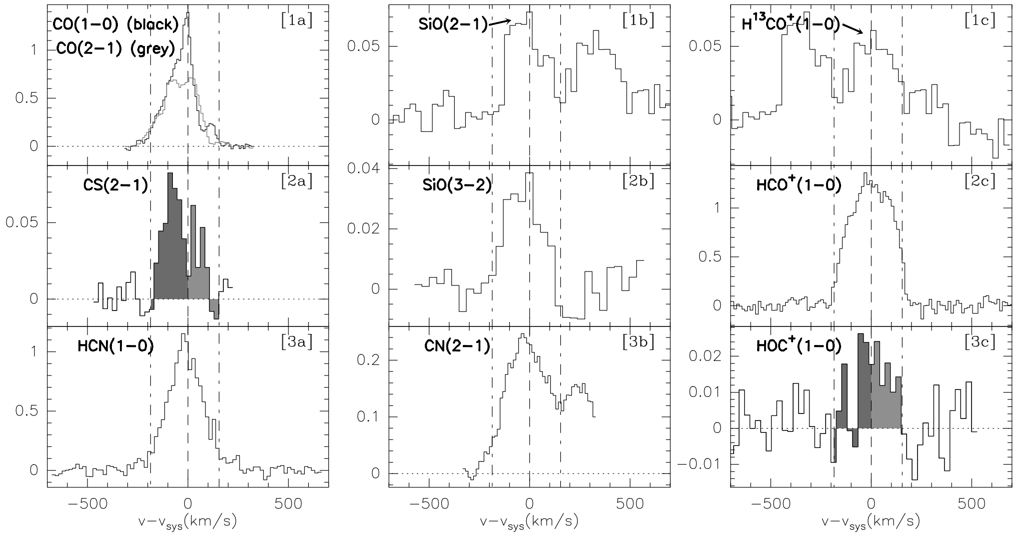

Figure 1. 30m Spectra of the Circumnuclear Disk (CND) in NGC 1068. Y-axis units are T_{MB} in Kelvin and X-axis units are radial velocities referred to v_{sys}^{LSR}=1126km/s. (from Usero et al. 2003)

The observed SiO emission implies large abundances of this molecule (SiO/H_2 $\sim 5\times10^{-9}$-10^{-8}) in the CND. An enhancement of SiO abundances in XDR is expected if the intense X-rays are able to evaporate the small (∼10 Å) silicate grains and subsequently increase the Si fraction in gas phase.

The observation of HOC^+ in NGC 1068 is the first extragalactic detection of this active radical. From LVG models we infer that HOC^+ is highly abundant in the CND of this galaxy: we measure a HCO^+/HOC^+ ratio ∼ 50, which is even lower than the smallest values found in galactic PDR (Fuente et al. 2003). HCO^+/HOC^+ ratios in XDR may be smaller than those measured in PDR due to the higher ionization degrees that take place in the former regions (Smith et al. 2002).

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