High Resolution 1-20μm Imaging of the Nuclear Environment of NGC 1068

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We present new mid-infrared continuum and near-IR line images of the nuclear environment of the nearby (14 Mpc) Seyfert 2 galaxy NGC 1068. The 8, 10 & 19 micron data were measured with our new mid-IR array camera, MIRACLE (Cameron *et al.* 1992a), at UKIRT in November 1991 while our images of the H_2 2.121μm and [Fe II] 1.64μm lines were obtained with FAST, the MPE imaging spectrometer, at the 4.2m William Herschel Telescope in August 1991. The MIRACLE data were imaged through narrow band ($\frac{\lambda}{\Delta\lambda} \geq 50$) filters whereas FAST incorporates a Fabry-Perot etalon ($\frac{\lambda}{\Delta\lambda} \geq 950$).

The 8 & 10 micron emission is resolved with respect to our $\sim$1″ point spread function (PSF) and, as such, these data represent the highest spatial resolution mid-IR images of NGC 1068 hitherto obtained. In addition, MIRACLE's good spatial sampling (0.17″/pixel) and the high signal-to-noise quality of our 10μm data has allowed us to effectively deconvolve the raw images. These deconvolved data, which have a resulting spatial resolution of 0.5″, are presented in Figure 1 (inset) superimposed on a map of the narrow line emission clouds obtained with the HST. It is apparent that the mid-infrared emission, which arises from dust heated to several hundred Kelvin, is extended on angular scales of $\sim$2″, corresponding to $\sim$140 pc at the distance of NGC 1068, along the direction of the outflow from the nucleus which is observed at radio wavelengths. The spatial distribution of the 10μm emission bears a striking resemblance to that of the optical [O III] emission. Such a spatial coincidence suggests an intimate link between the warm dust and narrow line clouds (Genzel, Cameron & Krabbe 1992; Cameron *et al.* 1992b).

The 2.121μm H_2 v=1-0 S(1) line data is shown in figure 1 superimposed on a map of the radio continuum emission. The warm circumnuclear molecular gas is extended $\sim$5″ (340 pc) east-west and consists of several embedded knots which represent concentrations of dense, massive molecular clouds. The brightest H_2 knot, centred 0.3″ south-west of the near-IR continuum peak, has a molecular hydrogen column density in excess of 10^{23} cm^{-2} and may contribute significantly to the large obscuration of the nucleus that is inferred from optical polarisation measurements. In contrast, the [Fe II] emission is extended over $\sim$7″, is elongated at position angle $\sim$35° and closely traces the narrow line region and the central collimated part of the radio jet (Blietz *et al.* 1992).

Based on these observations we propose a model of NGC 1068 in which the H_2 emission arises in warm gas heated by X-ray and UV radiation from the central source (Rotaciuc *et al.* 1991). The extended mid-IR emission may be explained as dust, located in clouds at the interface between the conical outflow channel and the circumnuclear ISM, which is *directly* heated by radiation from the active nucleus. In particular, our model does not require the presence of a thick, dusty, few parsec scale torus surrounding the nucleus but, rather, we pro-

pose that the bulk of the molecular material in the inner ~150 pc is actually located at large distances from the nucleus. In the absence of a compact dusty torus, our direct view of the nucleus is probably blocked by one or more molecular clouds located a few 10 pc from the AGN (Cameron *et al.* 1992b).

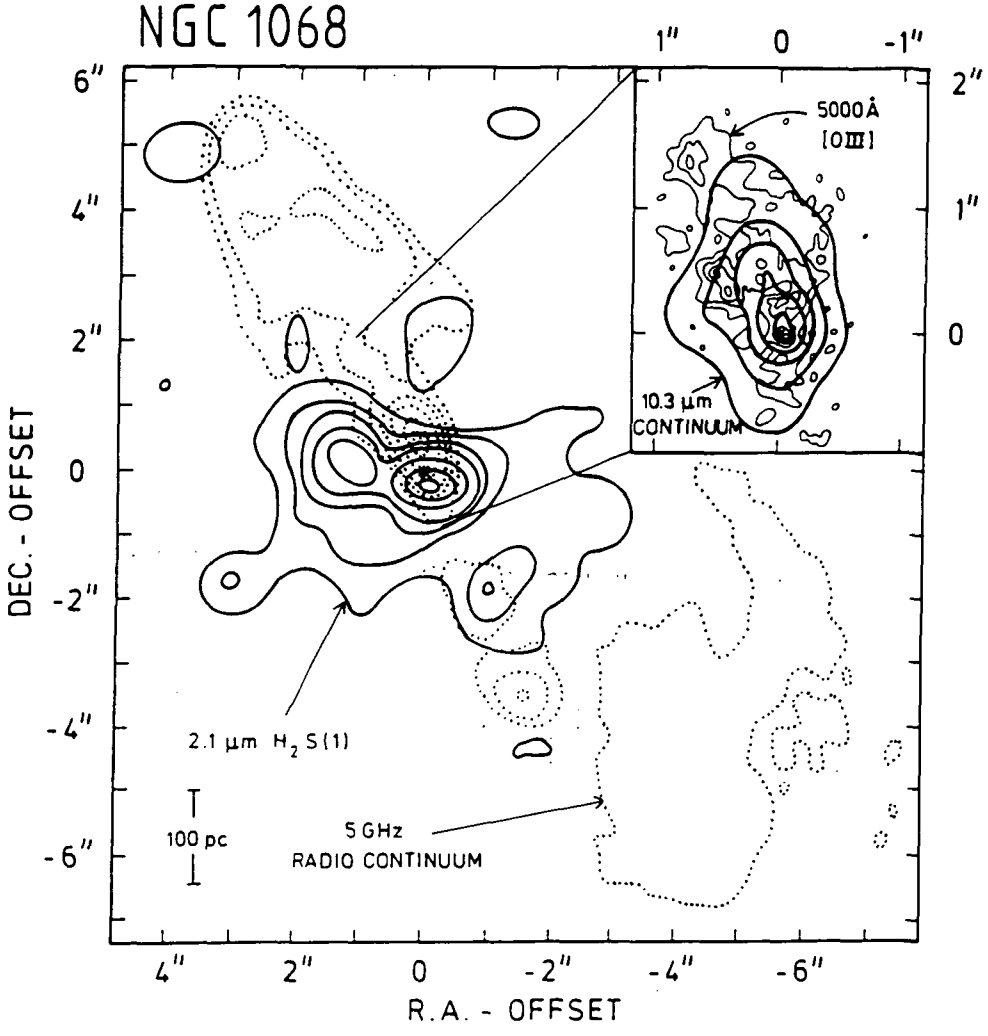

Figure 1: Image of the 2.121μm H_2 v=1-0 S(1) line obtained with the MPE imaging spectrometer (FAST) towards the nuclear region of NGC 1068 (solid lines) superimposed on the 5 GHz radio continuum map (dotted lines). The spatial resolution of the near-IR data is ~1". The inset shows the map of the deconvolved 10.3μm emission obtained with MIRACLE (thick lines) superimposed on an image of the narrow line clouds measured by the HST (thin lines). The effective spatial resolution of the mid-IR data is 0.5".

References

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