

NICMOS Observations of the Nuclear Star Cluster of NGC 1068

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Abstract. We analyzed archival Hubble Space Telescope NICMOS images of NGC 1068, with the goal of resolving a discrepancy between attempts at speckle imaging and observations of the near infrared variability. Using a surface-brightness fitting technique, we decomposed the central $2''.4$ (170 pc; square aperture) into two main components: (1) an unresolved source with very red near-infrared colors; and (2) an extended component with colors compatible with an evolved star cluster. The compact source makes up 84% of the $2.22 \mu\text{m}$ emission within the central $2''.4$, and the source size is smaller than 30 mas (2 pc; Thompson & Corbin 1999). The nuclear star cluster has a core diameter of ~ 50 parsecs, comparable to the distribution of CO bandhead absorption measured by Thatte et al (1997).

1. Introduction

Weinberger et al. (1999) presented Keck speckle imaging data of NGC 1068, offering the highest resolution near-infrared imaging of this source to date. The photometry of the Keck speckle image disagrees, however, with the source size limits imposed by near-infrared variability (Glass 1995). According to Weinberger et al., the K-band flux density of the central 70 LY is ~ 0.46 Jy. In contrast, the infrared light-curve constrains the diameter of a 0.46 Jy source to < 40 LY. Moreover, the nuclear point source can contribute no more variability than its 1995 flux density, ~ 0.23 Jy, limiting the size of the extended source to < 24 LY.

2. Comparison of the NICMOS and Keck Speckle Images

The $2.2\mu\text{m}$ resolution of NICMOS is $\sim 0''.2$, sufficient to resolve the luminous, elongated source reported by Weinberger et al. To make an appropriate comparison with the NICMOS image of NGC 1068, we convolved a model of the Keck speckle image with a model NICMOS $2.22\mu\text{m}$ PSF. The result was that the point source on the NICMOS direct image is significantly narrower than the convolved Keck model. Taken with the infrared variability argument described above, it

appears that the model of the Keck speckle image put forward by Weinberger et al. erroneously places too much luminosity into the putative extended source.

3. Surface Brightness Decomposition of the NICMOS Image

We further analyzed the NICMOS images by fitting PSF-convolved surface brightness models. The simplest, best-fit model comprised a single point source, constant background, and a King model surface brightness distribution. The resulting decomposition is summarized in Table 1.

Filter	Point Source		Extended		Core Radius		Residual
	S_ν (mJy)	Error	S_ν (mJy)	Error	r_C (pc)	Error	S_ν (mJy)
F110W	10.6	± 0.5	70.2	± 3.5	24.4	± 1.0	6.9
F160W	85.9	4.4	85.6	4.3	21.4	1.0	8.0
F222M	591.9	29.7	91.6	5.0	24.9	1.7	23.3

Table 1. Results of the surface brightness decomposition of the NICMOS images of NGC 1068. The unresolved nuclear source contributes 84% of the $2.2\mu\text{m}$ luminosity within the central $2''.4$.

4. Color Analysis

The nuclear point source is particularly red in NICMOS colors, even in comparison with other active nuclei. The NICMOS colors best fit emission from 600–700 K dust grains and a minor contribution from a “bluing” source that contributes an excess to the F110W filter; for example, an NLR-like line emission spectrum, contributing less than 1% to the total emission in the F222M filter, would produce the F110W excess. The nuclear point source is presumably dusty ISM located with 1 – 2 pc of the central engine.

The NICMOS colors of the extended source are compatible with an aging stellar cluster. The best match in NICMOS colors and $L_{222}/\text{Dynamical Mass}$ occurs for a cluster age of 100 – 200 Myr. These results are broadly consistent with the conclusions of Thatte et al. (1997), who imaged the near-nuclear distribution of CO bandhead absorption arising, apparently, from the same stellar cluster. Given this age constraint, we estimate that the nuclear stellar cluster contributes only $\sim 3\text{--}4\%$ of the bolometric luminosity of the nucleus.

References

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