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An accreting black hole in the nucleus of the bulgeless galaxy NGC 1042

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Abstract. Compact star clusters are commonly found in the centers of galaxies and may foster formation of intermediate-mass "seed" black holes that facilitate the growth of supermassive black holes in galaxy nuclei. Such star clusters can be studied with minimal background starlight contamination in bulgeless galaxies. We present new results that point to the presence of an accreting black hole associated with the central star cluster in the Sd galaxy NGC 1042, and discuss implications for the bulge-black hole connection.

Keywords. galaxies: nuclei, galaxies: active, galaxies: star clusters

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The appearance of luminous QSOs at $z > 6$ requires a growth mechanism for a central black hole that is rapid and possibly radiatively inefficient. The formation of seed black holes of intermediate mass ($\sim 10^2 - 10^6$ $M_\odot$) and subsequent accretion may facilitate the early formation of supermassive black holes that power the observed AGNs.

Dense star clusters provide one vehicle for generating intermediate mass black holes. Imaging surveys have revealed that compact clusters are commonly found in the centers of galaxies (Carollo *et al.* 1998; Böker *et al.* 2002; Grant *et al.* 2005; Côté *et al.* 2006). Remarkably, the ratio of cluster mass to bulge mass in these objects is the same as the ratio of black hole mass to bulge mass in galaxies where black holes have been measured (Ferrarese *et al.* 2006; Rossa *et al.* 2006).

NGC 1042 is an Sd galaxy and hosts a compact star cluster with properties resembling a luminous globular cluster (effective radius $r_e \sim 2$ pc, velocity dispersion $\sigma = 32$ km s^{-1}; Walcher *et al.* 2005). A detailed analysis of the stellar continuum indicates that it is dominated by old (> Gyr) stars, but like many nuclear clusters it shows evidence for younger components (Walcher *et al.* 2006). The optical spectrum also shows narrow emission lines.

Line flux ratios for the nucleus are consistent with a borderline AGN classification. The emission-line profiles show remarkable high velocity wings extending to ±200 km s^{-1} from line center (see Fig. 1). The Hα line is narrower than the forbidden lines, but this can be understood as emission from a separate H II-region component; while the peak forbidden line flux is coincident with the star cluster, the maximum Hα flux is spatially offset by $\sim 0.5''$. The emission-line ratios can thus be interpreted as a mix of emission from a central AGN and a nearby H II region.

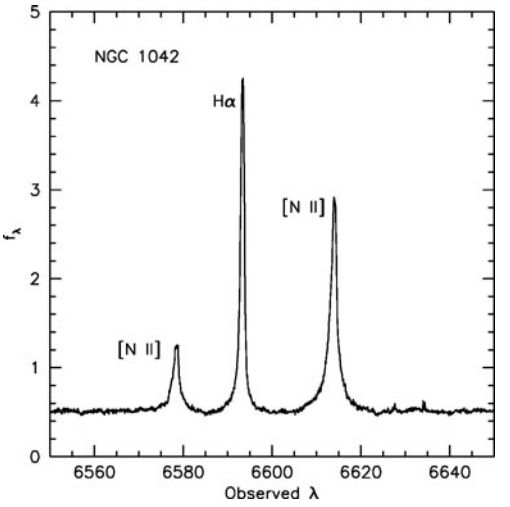

Figure 1. UVES spectra revealing high velocity wings on the emission lines.

The presence of AGN line emission in the center of NGC 1042 implies the presence of an accretion source presumably powered by a black hole. If NGC 1042 follows the $M_\bullet - \sigma$ relationship (Gebhardt *et al.* 2000; Ferrarese & Merritt 2000), the stellar velocity dispersion for the nucleus would predict a black hole mass of $M_\bullet \sim 8 \times 10^4$ M$_\odot$, thereby making this source the likely site of an intermediate-mass black hole.

Not all nuclear star clusters are associated with significant black holes; an important example is provided by M33, where analysis of stellar kinematics (Gebhardt *et al.* 2001; Merritt *et al.* 2001) for the central star cluster (with $\sigma = 21$ km s^{-1}) places a limit of $M_\bullet < 1500$ M$_\odot$. However, NGC 1042 joins NGC 4395 ($\sigma < 30$ km s^{-1}), the lowest luminosity Seyfert 1 galaxy, in presenting evidence of an intermediate-mass black hole associated with a nuclear star cluster in a bulgeless galaxy (Filippenko & Ho 2003). From reverberation mapping, the black hole in NGC 4395 has $M_\bullet \approx 4 \times 10^5$ M$_\odot$ (Peterson *et al.* 2005). Objects such as NGC 4395 and NGC 1042 may hold important clues to the origins of supermassive black holes and their relationship to bulges.

References

Böker, T., *et al.* 2002, *AJ*, 123, 1389
Carollo, C. M., Stiavelli, M., & Mack, J. 1998, *AJ*, 116, 68
Côté, P., *et al.* 2006, *ApJS*, 165, 57
Ferrarese, L. & Merritt, D. 2000, *ApJ*, 539, L9
Ferrarese, L., *et al.* 2006, *ApJ*, 644, L21
Filippenko, A. V. & Ho, L. C. 2003, *ApJ*, 588, L13
Gebhardt, K., *et al.* 2000, *ApJ*, 539, L13
Gebhardt, K., *et al.* 2001, *AJ*, 122, 2469
Grant, N. I., Kuipers, J. A., & Phillipps, S. 2005, *MNRAS*, 363, 1019
Merritt, D., Ferrarese, L., & Joseph, C. L. 2001, *Science*, 293, 1116
Peterson, B. M., *et al.* 2005, *ApJ*, 632, 799
Rossa, J. *et al.*, 2006, *AJ*, 132, 1074
Walcher, C. J., *et al.* 2005, *ApJ*, 618, 237
Walcher *et al.* 2006, *ApJ*, 649, 692

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