*Co-Evolution of Central Black Holes and Galaxies*
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# Fossil SMBHs in the Milky Way Halo

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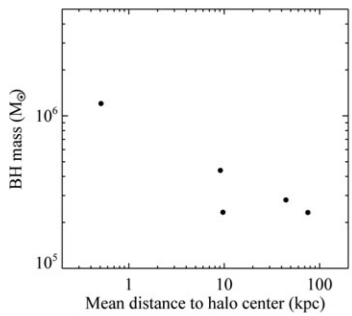
As galaxies assemble through hierarchical merging, some black holes grow to become the central black holes of massive galaxies; however, others may be stripped via interactions into regions of galaxies where they will remain quiescent. Such objects may be the source of observed off-nuclear intermediate-mass black hole candidates, as detected by Farrell *et al.* (2009). We use a cosmological $N$-body simulation of a disk-dominated galaxy ($V_c = 140$ km s$^{-1}$, presented by Governato *et al.* 2009) to examine the formation and merging histories of seed black holes during hierarchical assembly. Our method incorporates star formation, supernova feedback, a physically motivated description of black hole seed creation, growth, and merging.

We run a cosmological simulation of a Milky Way-mass galaxy with GASOLINE, a SPH KD Tree code which incorporates gas hydrodynamics, star formation, supernova feedback, turbulent metal diffusion, and relevant black hole (BH) physics. BH seeds form early in the galaxy's history, but formation quickly ceases by $z \sim 3.5$ due to the diffusion of metals through the ISM and IGM. The galaxy undergoes a major merger at $z = 2$ and another at $z = 0.8$, reforming a large disk shortly afterward (see Governato *et al.* 2009). During major mergers, the primary BHs in each galaxy also merge rapidly, but small halos in minor mergers get tidally stripped, leaving their BHs to "wander" throughout the primary halo. At redshift $z = 0.4$, the halo has a total mass of $1.75 \times 10^{12}\ M_\odot$, a virial radius of 342 kpc, and a circular velocity of 140 km s$^{-1}$. The primary black hole has a mass of $2 \times 10^6\ M_\odot$, and the four "wandering" black holes have masses between $\sim 2$–$5 \times 10^5\ M_\odot$ at time-averaged distances from the center of 9–75 kpc. If these black holes are on radial orbits similar to their progenitor halos and pass through the Galactic disk, they may be the source of observed off-nuclear intermediate-mass black hole candidates, as detected by Farrell *et al.* (2009).



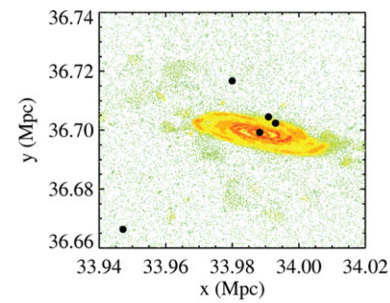




**Figure 1.** *Left:* Distribution of BHs. *Right:* Gas density map with BHs identified as filled circles.

**References**

Begelman, M. C., Volonteri, M., & Rees, M. J. 2006, *MNRAS*, 370, 289
Farrell, S. A., Webb, N. A., Barret, D., Godet, O., & Rodrigues, J. M. 2009, *Nature*, 460, 73
Governato, F., *et al.* 2009, *MNRAS*, 398, 312