The Merger History of Supermassive Black Holes in Galaxies

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The Population of Supermassive Black Holes

- Quasar (Optical) Luminosity Function

(e.g. Richstone et al. 1998)

- Comoving density of luminous quasars ($M_B \lesssim -26$) peaks around $10^{-6}\ Mpc^{-3}$ at $z \sim 3$, vs. $\sim 10^{-3}\ Mpc^{-3}$ for the corresponding host galaxies ($M_B \lesssim -20.7$)

$\rightarrow$ SMBHs are present in at least a fraction $\sim 10^{-3}$ of these bright galaxies

- X-Ray Studies

(Mushotzky et al. 2000; Barger et al. 2001)

$\sim 10\%$ of all bulge-dominated optically-luminous galaxies show hard X-ray activity ($M_I \lesssim -22.5$, $z < 3$)

$\rightarrow$ presumably associated with a SMBH

- Dynamical Studies (Magorrian et al. 1998)

- SMBHs are almost ubiquitous in nearby galaxies
- galaxy masses probed extensively: $M \gtrsim 10^{11}\ M_\odot$ ($M_v \lesssim -20$)

Implications

• SMBHs could be rare in galaxies at $z \geq 3$ (occupation fraction of a few % or more at $z = 5$), with consequences for the interpretation of the quasar luminosity function and clustering properties

• Minimum event rate for *LISA* is encouraging ($\gtrsim 10\ \mathrm{yr}^{-1}$ out to $z = 5$) if SMBH binaries merge efficiently

• A population of wandering SMBHs in galaxies (and SMBH binaries) seems likely if SMBH binaries do not merge efficiently