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Central black hole masses in ultraluminous X-ray sources

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Ultra-luminous X-ray sources(ULXs) are off-nuclear X-ray sources in
nearby galaxies with X-ray luminosities $L_{\rm X} > 10^{39}$ erg s^{-1}. The estimates of black hole(BH) masses of ULXs is a
long-standing problem. Here we estimate BH masses of ULXs from both
the X-ray photon index and X-ray variability using the correlations
derived from reverberation mapping active galactic nuclei (AGNs),
and discuss whether the results are in agreement with each other. We
find that some high-luminosity($L_{\rm X} > 10^{40.5}$ erg s^{-1}) ULXs contain the BH of 10^4-10^5 $M_\odot$.
While the X-ray variability for some low-luminosity($L_{\rm X} < 10^{40.5}$ erg s^{-1}) ULXs suggests larger masses, which
are in conflict with that from X-ray photon index. This may indicate that some low-luminosity ULXs generally accrete at different rate as luminous AGNs, or they have different power spectral densities of X-ray variability.

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We discuss two methods to estimate black hole (BH) masses using
X-ray data only: from the X-ray variability amplitude and from the
photon index Γ.

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