Dark Matter Accretion into Supermassive Black Holes

Peirani et al.
Physical Review, 2008
• An analytic approach to solve for the accretion rate of dark matter into black holes located in the centre of galaxies and their halos.
• The accretion model is described by a relativistic steady spherically symmetric inflow of dark matter into the black hole
• The assumption for this model is that the phase space indicator $Q = \rho/\sigma^3$ remains constant during the inflow
• The above hypothesis is equivalent to saying that the inflow is adiabatic – since entropy density satisfies $s \propto -\log Q$
FINDINGS

• The critical radius is found to be always outside the black hole horizon (for typical host halos, critical radius is 30-150 times the horizon radius).

• The flow radial velocity at the critical point is of the order of a few percent of the speed of light.

• After crossing the critical point, numerical solutions of the equations describing the flow show that the velocity and density have power law profiles:

\[ u \propto \frac{1}{r^{0.6}} \quad \rho \propto \frac{1}{r^{1.4}} \]
The black hole accretion rate is given by:

\[
\frac{dM_{bh}}{dt} = \frac{27\pi}{\sqrt{125}} (GM_{bh})^2 Q
\]

- here, the dark matter phase space indicator,
  \[Q = \rho_\infty/\sigma_\infty^3\]
  , where \(\rho_\infty\) is the dark matter density far away from the black hole, where the flow velocity is negligible; \(\sigma_\infty\) is the velocity dispersion of the dark matter particles.

- The rate given above is higher by about five orders than the accretion rate for black holes hosted by typical dark halos, where we deal with non-relativistic and non-interacting particles.
NUMERICAL APPLICATIONS

- Numerical applications of the derived formula were made by computing the growth of black holes inside halos issued from cosmological simulations.
- Final mass of Halo 211 is $7.46 \times 10^{11} M_{\text{Solar}}$ and of Halo 3 it is $8.06 \times 10^{12} M_{\text{Solar}}$

**Dark matter contributes not more than 10% of the total accreted mass**

![Graphs showing mass evolution and dark matter fraction](image)

Fig: Left panel shows the mass evolution of black holes. Right panel shows the evolution of fraction of accreted dark matter.
BARYONIC AND DARK MATTER
ACCRETION RATES COMPARED

- Different peaks in baryonic accretion rate are associated with major or minor mergers. Max. rate occurs at $z = 1.5$
- Baryonic accretion rate will probably be reduced by a factor of 2-6 if star formation process is included, based on detailed cosmological simulations.