Growth of Supermassive Black Holes

Ji-hoon Kim

2018/12/26

1 Note To Students

Following the spirit of past winter camp projects, the following questions are, as of this writing, still completely open for active research and ongoing debates. Students are welcomed to challenge themselves to push their limits, and see how far down the list they can go. Good luck!

2 Baryonic Accretion Onto A Black Hole

Imagine a seed black hole of mass $10^6\,M_\odot$ sitting at the center of a large spiral galaxy like our own Milky Way. Assume that there is a very large reservoir of baryons and dark matter in the vicinity of the black hole; that is, the black hole's growth is limited *not* by the amount of materials available for accretion, *but* only by the fundamental physical processes that you will consider below.

(1) Let us first assume that the black hole is growing by devouring baryons in its neighborhood. There is a fundamental limit to the rate of this baryonic accretion, called the Eddington limit. Explain what it is. What are the assumptions that need to be made for the Eddington limit argument? Explain how fast our seed black hole could double its mass assuming the Eddington-limited accretion. Is the rate fast enough to resolve the puzzle of supermassive black holes at redshift $z > 7$ in our Universe (e.g., Mortlock et al. 2011; Banados et al. 2018)?

3 Dark Matter Accretion Onto A Black Hole

A black hole is a great portal that connects the baryonic sector and the dark matter sector. That is to say that a black hole might have grown by devouring only dark matter and yet, to us, a baryonic black hole and a dark matter black hole would be largely indistinguishable.

(2) Estimate how fast our seed black hole could grow if we assume that its growth is by only "cold" dark matter accretion. What are the assumptions you made about the accretion process? What are the assumptions other researchers made in previous estimates (e.g., Peirani & Pacheco 2008)?

(3) Now consider alternative models of dark matter. For example, what if we assume a "warm" or "self-interacting" dark matter model? Explain the specific dark matter model you considered, and estimate how fast the black hole could grow by devouring only your particular type of dark matter particles. What are the other assumptions you made about the accretion process? What are the models and assumptions other researchers considered in previous studies (e.g., Pollack et al. 2015)?

(4) Now consider another alternative model of dark matter, a "dissipative dark sector" model. Explain the specific dark matter model you considered, and estimate how fast the black hole could grow. What are the other assumptions you made about the accretion process? What are the models and assumptions other researchers considered in previous studies (e.g., D'Amico et al. 2018, Outmazgine et al. 2018)?