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The Dynamics of Seed Black Holes in the First Galaxies

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ABSTRACT

Copied from AAS. Should be updated before submission with main results. The discovery of bright quasars at redshift $z \geqslant 6$ in the Sloan Digital Sky Survey implies that black holes (BHs) as massive as $10^9 M_\odot$ were already assembled within 1 Gyr. Generically, these SMBHs are thought to have assembled by mergers with other BHs and by gas accretion onto less massive seed BHs. One candidate of such seed BHs are Population III (Pop III) stellar remnants. In order to map out plausible scenarios such massive objects form from Pop III remnants, we run a cosmological adaptive refinement mesh simulation of an overdense region of about 300 Mpc^3, which forms a few $10^9 M_\odot$ dark matter halos and over 13000 Pop III stars by redshift 15. Then we focus on one of these massive halos, containing 20 Pop III stellar remnants, to study the dynamical behavior of these BH seed candidates. Here we report on the evolution of the orbital properties of stellar-mass seed BHs in one of the first galaxies. They are distributed throughout the halo, creating a swarm of BHs, gradually falling toward the halo center through dynamical friction. From these characteristics, we estimate the BH merger rate in this particular galaxy, which is an important quantity to assess during the early buildup of massive BHs.

Key words: galaxies: formation – galaxies: dwarf – galaxies: high-redshift – methods: numerical

1 MOTIVATION

* mention Haiman's paper, which is semi-analytical.
we did a full numerical study.

2 METHODS

2.1 Simulation Setup

*Brief description of Enzo
star formation and feedback(ref: Wize et al. (2012a, 2012b) and Xu et al.(2013)

*Initial condition (MUSIC)
Cosmological parameters(δ – overdensity), Ωs, size of sim box
DM mass resolution, time span(in terms of redshift)

*Further zoom-in simulation description
John's simulation on Bluewater(for more representative massive halos)

2.2 Orbital Elements

*approximation: key orbital properties of seed BHs: semi-major axes and eccentricities
calculation of semi-major axis and eccentricities
Angular momentum and estimation of merger rate by the evolution.

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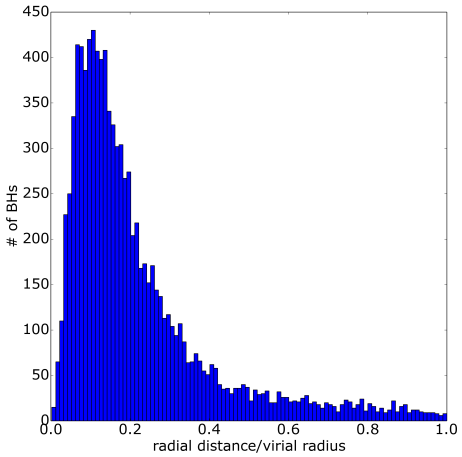
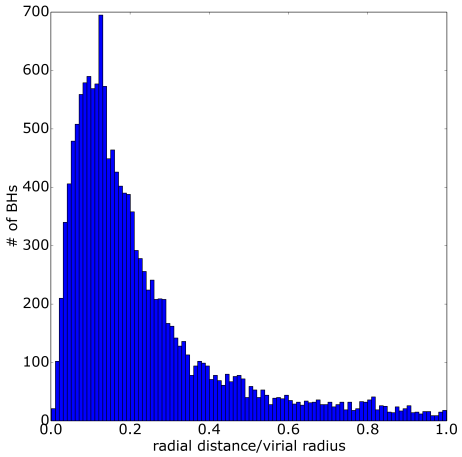
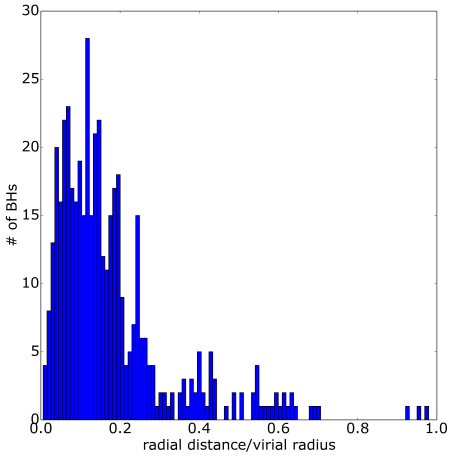




3 RESULTS

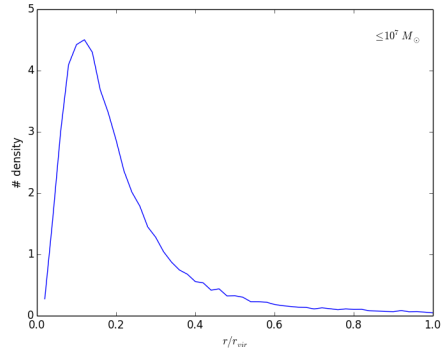
3.1 Stacked Analysis

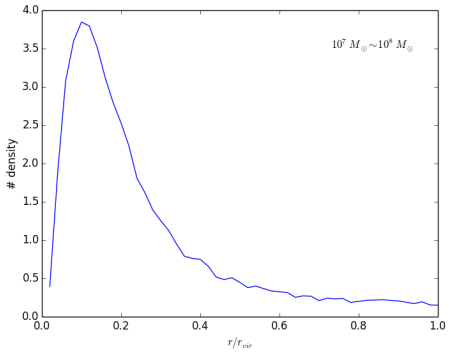
Radial distribution of seed BHs at different stages:



Radial distribution of seed BHs of the final time step in different mass ranges:

Orbital properties:





3.2 Case Study: High Temporal Analysis of a Single Galaxy

Seed BHs position:

Angular momentum evolution:

ACKNOWLEDGMENTS

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References

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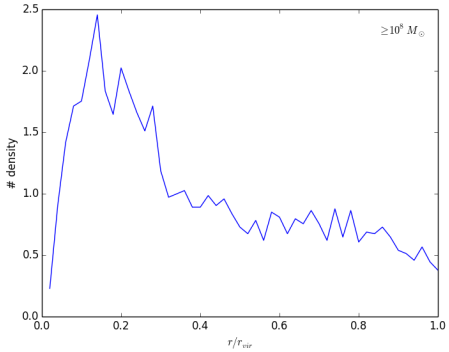

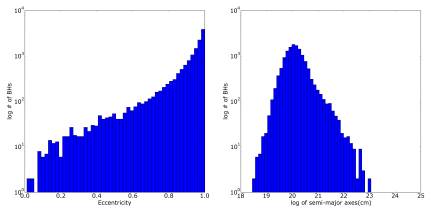

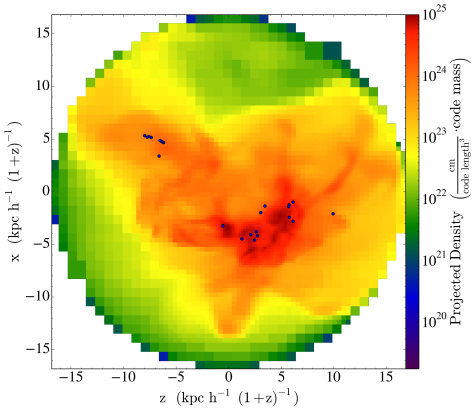

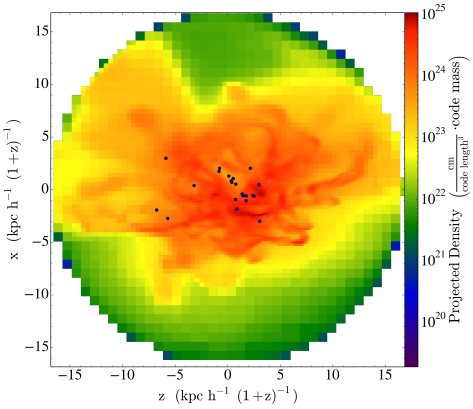

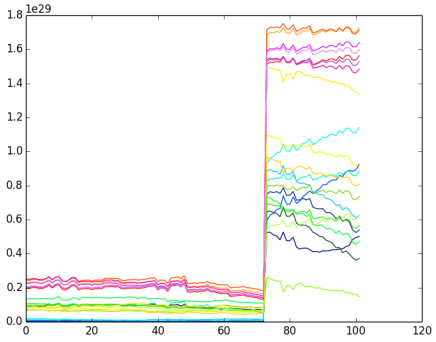

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