Database Overview

1 Simulation Summary

The code used for this simulation is the massively parallel cosmological TreePM-SPH code GADGET3 [11], with the addition of a multi-phase modeling of the ISM, which allows treatment of star formation [10] and black hole accretion and associated feedback processes [6, 9].

Black holes are modeled as collisionless sink particles according to a sub-resolution model which inserts seed black holes (with $m_{\rm seed} = 5 \times 10^5\ h^{-1}\ M_\odot$) into any halo (found by a friends-of-friends algorithm) above $5 \times 10^{10} h^{-1} M_\odot$. These seed black holes then grow by accretion of surrounding gas (according to Bondi-Hoyle accretion) and by merging with nearby black holes. The BHs also radiate with a radiative efficiency of $\eta = 0.1$, and 5% of this liberated radiation couples thermally with the surrounding gas. For a more complete explanation of the simulation methods and model details, see [5]. For investigations into the black hole model and similar studies using these models, please see [1–5, 7, 8].

This database is based on the E5 simulation run by Yu Feng at Carnegie Mellon University. The parameters used in this simulation are listed in Table 1.

2 Database Summary

The black hole information is stored within the database in the following tables.

Table 1: Simulation Parameters

Boxsize	$100\ h^{-1}$ Mpc
Number of particles	2×336^3
$m_{\rm DM}$	$2.09 \times 10^8 h^{-1} M_\odot$
Ω_M	0.275
Ω_Λ	0.725
h	0.702
Starting Redshift	159
Ending Redshift	0
BH Radiative Efficiency (η)	0.1

2.1 blackholes

This table contains the full list of black hole properties. Every time the simulation calculates a BH's properties, the complete set of BH properties are saved, represented by a single line.

bhid: The internal ID assigned to the black hole.

time_q: The cosmological scale factor (a) for the given timestep.

mass: The black hole mass.

mdot: The black hole accretion rate.

rho: The local gas density.

csound: The sound speed of the surrounding gas.

vrel: The velocity of the black hole relative to the surrounding gas.

pos_x,y,z: The comoving coordinates of the black hole.

vgas_x,y,z: The velocity of the surrounding gas.

2.2 mergeeventsext

This table contains the information for every black hole merge which occurs.

time_q: Scale factor at which the merger occured

bh1: ID of one of the merging BHs

bh2: ID of the other BH

mass1: Mass of the first BH (bh1)

mass2: Mass of the second BH (bh2)

tid: A post-processing number assigned to every BH merger tree. This can be used to quickly find all BHs which belong to the same merger tree, i.e. all BHs which eventually merge by the end of the simultion.

NOTE: When a pair of black holes merge, the ID of the resultant black hole will always be that of bh1.

2.3 time_q_count

Table containing information about the number of black holes at each timestep.

time_q: Scale factor of the given timestep.

count_q: The number of black holes whose properties were saved at this timestep (which may not be all the black holes in the simulation at that time).

n_bh_total: The total number of black holes in the simulation at this timestep.

2.4 bhid_count

Table containing the number of timesteps at which a given black hole properties were recorded.

bhid: ID of the black hole.

count_bh: The number of timesteps at which the properties were recorded (i.e. the number of entries in the 'blackholes' table with this id).

NOTE: This treats each BH ID as a unique object, so black hole mergers are not considered here.

2.5 bhid_tid

Table containing every BH ID and the merger tree to which it belongs.

bhid: ID of the black hole.

tid: The merger tree to which the BH belongs (see MergeEventsExt table).

2.6 mergecounts

Table containing number of mergers which occur in each merger tree.

tid: The merger tree id (see MergeEventsExt table).

nmergers: The number of mergers found in this merger tree.

3 Sample SQL Queries

The database was designed for use with SQLite3. For those unfamiliar with SQL queries, we recommend looking at one of the many SQL tutorials available online (such as the SDSS SQL Tutorial). We have also provided several sample queries here to get started. These queries were tested on a moderate consumer laptop, and all completed within ~ 1 second.

Get complete list of all black hole IDs, masses, and accretion rates at z=2 which have mass of at least $10^8 h^{-1} M_\odot$:

SELECT bhid, mass, mdot FROM blackholes WHERE time_q = 0.499638 AND mass > 0.01;

Get complete list of all mergers in the merger tree containing BH 30104331:

SELECT mergeeventsext.* FROM mergeeventsext, bhid_tid WHERE bhid_tid.bhid=30104331 AND mergeeventsext.tid=bhid_tid.tid;

Get complete history of all BHs in the merger tree containing BH 30104331:

SELECT blackholes.* FROM blackholes, bhid_tid WHERE blackholes.bhid=bhid_tid.bhid and bhid_tid.tid=(SELECT tid FROM bhid_tid WHERE bhid=30104331);

Get complete list of all BHs which grow to at least $10^9 h^{-1} M_\odot$ by the end of the simulation, along with their final mass

SELECT bhid, max(mass) FROM blackholes INDEXED BY bh_mass WHERE mass > .1 AND bhid NOT IN (SELECT bh2 FROM mergeeventsext) GROUP BY bhid;

NOTE: The clause *bhid NOT IN (SELECT bh2 FROM mergeeventsext)* is used to avoid getting multiple IDs of BHs found in the same merger tree.

References

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