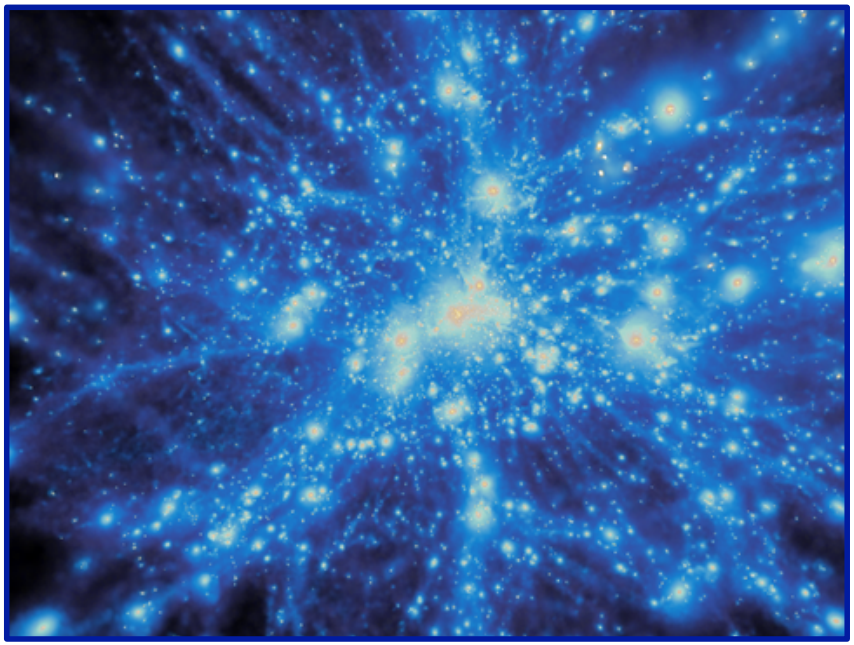
The MultiDark Database for Cosmological Simulations

Ginevra Favole
on behalf of the MultiDark-AIP Collaboration
Instituto de Astrofísica de Andalucía IAA-CSIC, Granada



Cosmology meets Machine Learning
NIPS 2011, Granada

Database Web Interface

Interactive access through web interface: www.multidark.org

Access to data via standard SQL queries

History of previous queries & demo queries

Scripted access for IDL, R, Topcat: wget.multidark.org/MyDB

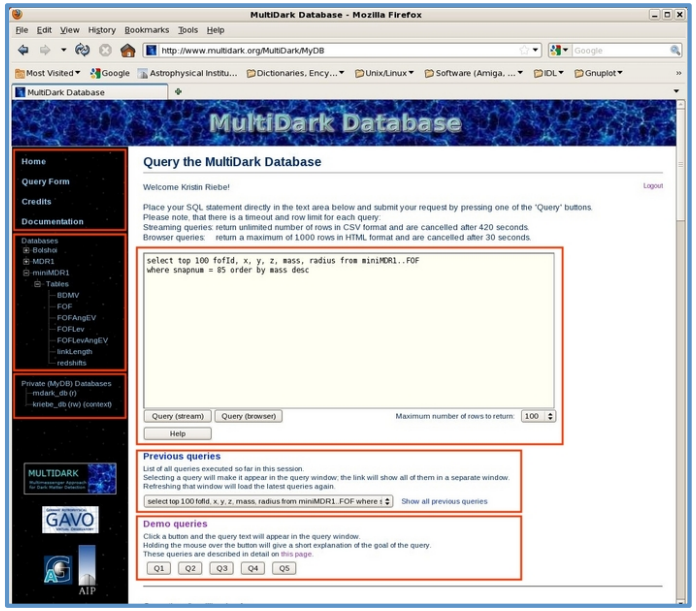
Private DB space (registered users)

Extensive documentation and collection of useful queries

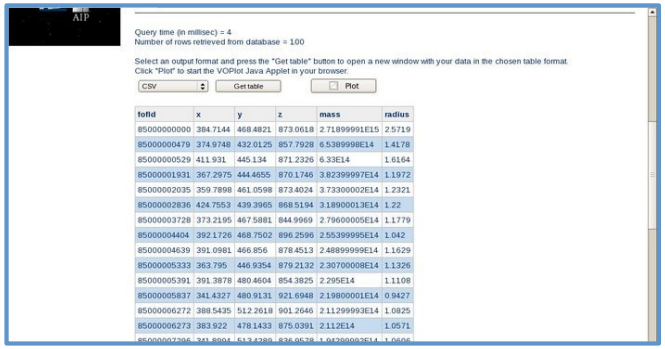
DB Team:

Adrian Partl, Kristin Riebe, Harry Enke, Stefan Gottlöberg, Francisco Prada, Anatoly Klypin, Gerard Lemson, Arman Khalatyan, Jaime Forrero, Sebastian Trujillo, Ginevra Favole

QUERY FORM...



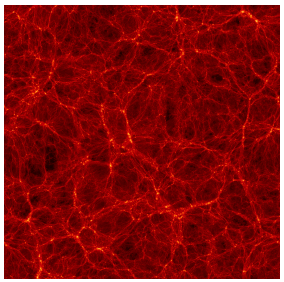
...RESULT



Simulations and Halo Catalogues

Bolshoi

Klypin, A., Trujillo-Gomez, S., Primack, J., 2010, arXiv: 1002.3660

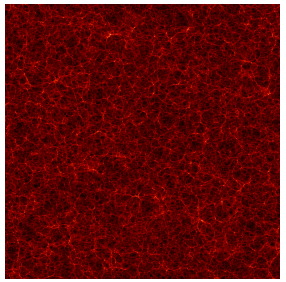


Box size (250 Mpc/h)^3
Number of particles $2048^3 \simeq 8.6$ billions
Mass resolution 1.35 x 10^8 M_{sun}/h
Force resolution 1.0 kpc/h
Initial redshift 80
WMAP5 cosmology

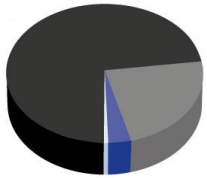
MultiDark MDR1

Prada, F. et al., 2011, arXiv: 1104.5130

Box size (1 Gpc/h)^3
Number of particles $2048^3 \simeq 8.6$ billions
Mass resolution 8.721 x 10^9 M_{sun}/h
Force resolution 7kpc/h
Initial redshift 65
WMAP5 Cosmology



ΛCDM
Cosmological Model
Initial conditions

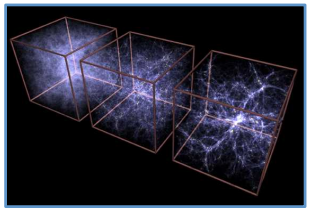


WMAP5

h	0.70	Hubble parameter
Ω_Λ	0.73	density parameter for dark energy
Ω_m	0.27	density parameter for matter (DM+baryons)
Ω_b	0.0469	density parameter for baryonic matter
n	0.95	normalization of the Power spectrum
σ_8	0.82	amplitude of mass density fluctuation in 8 Mpc/h sphere at z=0

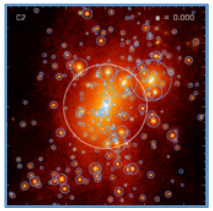
run a large simulation → pre - analyse → store data

SNAPSHOTS



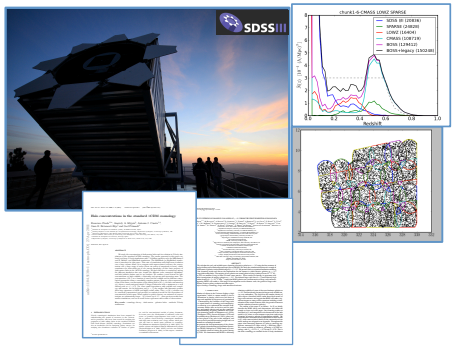
MDR1: 43 snapshots between 10.34< z <0
Bolshoi: 187 snapshots between 17.4< z <0

HALO FINDER

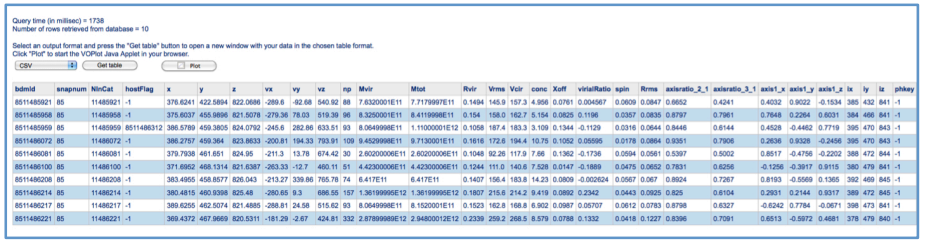


circles mark halos,
self-bound structures
possible locations for galaxies

analyse → compare with observations → store data



HALO CATALOGUES: position, velocity, mass, radius...for each halo

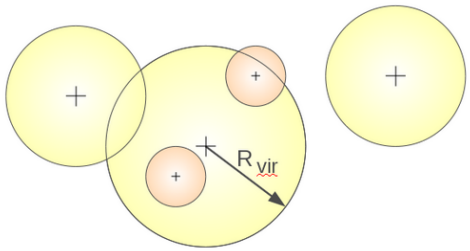


bdmid	snapnum	NlnCat	hostFlag	x	y	z	vx	vy	vz	np	Mvir	Mtot	Rvir	Vrms	Vcir	conc	Xoff	virialRatio	spin	Rrms	axisratio_2_1	axisratio_3_1	axis1_x	axis1_y	axis1_z	lx	ly	lz	phkey
8511485921	85	11485921	-1	376.6241	422.5894	822.0686	-289.6	-92.68	540.92	88	7.6320001E11	7.7179997E11	0.1494	145.9	157.3	4.956	0.0761	0.004567	0.0609	0.0847	0.6652	0.4241	0.4032	0.9022	-0.1534	385	432	841	-1
8511485958	85	11485958	-1	375.6037	455.9896	821.5078	-279.36	78.03	519.39	96	8.3250001E11	8.4119998E11	0.154	158.0	162.7	5.154	0.0825	0.1196	0.0357	0.0835	0.8797	0.7961	0.7648	0.2264	0.6031	384	466	841	-1
8511485959	85	11485959	8511486312	386.5789	459.3805	824.0792	-245.6	282.86	633.51	93	8.0649998E11	1.1100001E12	0.1058	187.4	183.3	3.109	0.1344	-0.1129	0.0316	0.0644	0.8446	0.6144	0.4528	-0.4462	0.7719	395	470	843	-1
8511486072	85	11486072	-1	386.2757	459.364	823.8633	-200.81	194.33	793.91	109	9.4529998E11	9.7130001E11	0.1616	172.6	194.4	10.75	0.1052	0.05595	0.0178	0.0864	0.9351	0.7906	0.2636	0.9328	-0.2456	395	470	843	-1
8511486081	85	11486081	-1	379.7938	461.651	824.95	-211.3	13.78	674.42	30	2.60200006E11	2.60200006E11	0.1048	92.26	117.9	7.66	0.1362	-0.1736	0.0594	0.0561	0.5397	0.5002	0.8517	-0.4756	-0.2202	388	472	844	-1
8511486100	85	11486100	-1	371.6952	468.1314	821.6387	-263.33	-12.7	460.11	51	4.42300006E11	4.42300006E11	0.1244	111.0	140.6	7.528	0.0147	-0.1889	0.0475	0.0652	0.7831	0.6256	-0.1256	-0.3917	0.9115	380	479	841	-1
8511486208	85	11486208	-1	383.4955	458.8577	826.043	-213.27	339.86	765.78	74	6.417E11	6.417E11	0.1407	156.4	183.8	14.23	0.0809	-0.002624	0.0567	0.067	0.8924	0.7267	0.8193	-0.5569	0.1365	392	469	845	-1
8511486214	85	11486214	-1	380.4815	460.9398	825.48	-280.65	9.3	686.55	157	1.36199995E12	1.36199995E12	0.1807	215.8	214.2	9.419	0.0892	0.2342	0.0443	0.0925	0.825	0.6104	0.2931	0.2144	0.9317	389	472	845	-1
8511486217	85	11486217	-1	389.6255	462.5074	821.4885	-288.81	24.58	515.62	93	8.0649998E11	8.1520001E11	0.1523	162.8	168.8	6.902	0.0987	0.05707	0.0612	0.0783	0.8798	0.6327	-0.6242	0.7784	-0.0671	398	473	841	-1
8511486221	85	11486221	-1	369.4372	467.9669	820.5311	-181.29	-2.67	424.81	332	2.87899988E12	2.94800012E12	0.2339	259.2	268.5	8.579	0.0788	0.1332	0.0418	0.1227	0.8396	0.7091	0.6513	-0.5972	0.4681	378	479	840	-1

Halo Finders

Bound density maximum (BDM)

Klypin, A., Holtzman, J., 1997, arXiv: 9712217



The algorithm detects local density maxima, impose a spherical cut-off for the halo and removes unbound particles. The latest version distinguish between halos and subhalos.

According to the overdensity criterion chosen, two classes of catalogues are produced:

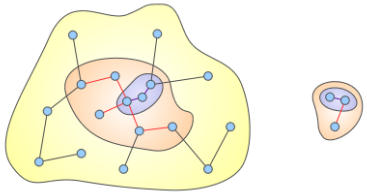
BDMV: average density **360•ρ_{back}**

BDMW: average density **200•ρ_{c}**

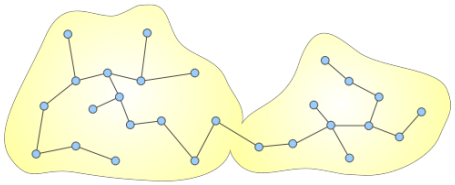
Friends-of-Friends (FOF)

Knebe, A., et al., 2011, arXiv: 1104.0949v1

Particles are linked together if their distance lies below the "linking lenght", corresponding to a density threshold.
FOF groups are listed by their linking lenght (6 levels: 0.17, 0.085, ...).

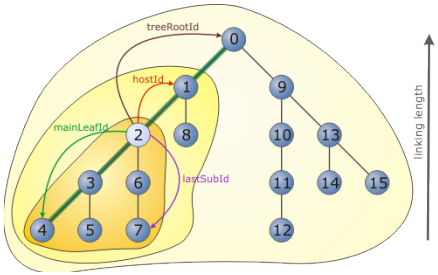


FOF groups with different linking lengths (yellow, orange, violet): substructures are defined as FOF groups which have a smaller linking length and lie inside a larger host halo. By definition, they always lie completely within their host.



FOF groups cannot intersect. If two objects come close enough (distance smaller than the linking length), they combine via a FOF bridge and are treated as one object.

Substructure merging trees are also included.



www.multidark.org