The v^2 GC model: the galaxy formation model with the large cosmological *N*-body simulation

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Collaborators

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The v^2GC Model

- "New Numerical Galaxy Catalog"
 - Updated version of the "vGC" model (Nagashima +2005)
 - semi-analytic galaxy formation model
- Major update: the *N*-body simulations of dark matter halos (Ishiyama+2015)
 - unprecedented box size and mass-resolution
- Baryon physics : gas cooling, heating by the UV background, star formation, SN feedback, AGN feedback, chemical enrichment, galaxy merger...
- The mock galaxy catalog will be publicly available soon

Cosmological dark matter simulation (Ishiyama et al. 2015)



Parameters of N-body simulations

Name	N	$L(h^{-1}\mathrm{Mpc})$	$m(h^{-1}M_{\odot})$	$M_{\min}(h^{-1}M_{\odot})$	#Halos	$M_{ m max}(h^{-1}M_{\odot})$
ν^2 GC-L	8192^{3}	1120.0	2.20×10^8	$8.79 imes 10^9$	421,801,565	4.11×10^{15}
$ u^2$ GC-M	4096^{3}	560.0	2.20×10^8	8.79×10^9	52,701,925	2.67×10^{15}
ν^2 GC-S	2048^{3}	280.0	2.20×10^8	$8.79 imes 10^9$	6,575,486	1.56×10^{15}
ν^2 GC-SS	512^{3}	70.0	2.20×10^8	$8.79 imes 10^9$	103,630	$6.58 imes 10^{14}$
ν^2 GC-H1	2048^{3}	140.0	2.75×10^7	$1.10 imes 10^9$	5,467,200	4.81×10^{14}
ν^2 GC-H2	2048^{3}	70.0	3.44×10^6	1.37×10^8	4,600,746	4.00×10^{14}
ν^2 GC-H3	4096^{3}	140.0	3.44×10^6	1.37×10^8	44,679,543(z=4)	$1.15 \times 10^{13} (z=4)$

- Planck cosmology
- With the highest mass-resolution, we can resolve the halo below jeans mass (circular velocity of ~ 17 km/s)
- With the largest box, we can expect ~10,000 of quasars at $z \sim 2$
 - enough to derive the auto-correlation function



Results

Luminosity functions and HI mass function



local SMBHs



• In our model, SMBHs increase its mass during major merger

• bulge component is formed as a merger remnant

cosmic star formation history



• The model well reproduces the observations

• A large amount of star formation activity has not yet been observed at high-*z*

Redshift evolution of *K*-band LF



- The model reproduces the bright-end of *K*-band LFs even at z = 2.0
 - AGN feedback works well
- low-mass galaxies are overproduced

The remaining issue: dwarf galaxies





- In our model, dwarf galaxies are metal poor, gas poor, too red, and overproduced at high-*z*
- low-mass galaxy happens too early and is overquenched at later times
- Model of SF and SN feedback are need to modify

Summary

- We construct the new model of galaxy and AGN formation
- The model well reproduces the properties of local galaxies and SMBHs, and cosmic star formation history
- The remaining issue : low-mass galaxy happen too early and is overquenched at later times
- The numerical catalog of galaxies produced by our model will be publicly available soon
 - Please contact us if you are interested in our model!
 - The catalog of dark matter halos are already available at http://www.imit.chiba-u.jp/faculty/nngc/
- Future work : redshift space distortion, clustering properties of quasars, cosmic IR background, sub-millimeter galaxies