First Generation Objects

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Structure of the talk

- **Original project goals and subprojects**
- **Original members**
- **Change of subprojects and members**
- **Final achievements (mostly as of early 2015)**

Original project goals

- To develop algorithms and simulation codes for simulations of dark matter halo, galaxy formation, star formation and planetary formation, which can effectively utilize the performance of K computer and other supercomputers of near future.
- Using the developed simulation code, study
  - The formation process of dark matter halos from the smallest-sized halos,
  - Galaxy formation process, in particular the origin of their varieties.
- Also study the star formation and planetary formation, in particular the origin of the variety of exoplanets.

Original goals — “quantitative”(1)

- For the simulation of dark matter halos, achieve the efficiency of 25-50% of the theoretical peak of K computer on near-full-node parallel calculation.
- For both large ($\sim$ 100Mpc) and small ($\sim$ 100pc) dark matter halo simulations, achieve the resolutions of at least 8192^3 and ideally 16384^3.
- For galaxy formation simulations, achieve the efficiency of 10-20% for the calculation with 1/10 of K computer.
- For galaxy formation simulations, perform 10^8 or more SPH particles, mass resolution of 100-1000 $M_\odot$

Original schedule

- **FY2011: Tuning and optimization of simulation codes for dark matter halos and galaxy formation**
- **FY2012: Perform large-scale calculation for dark matter halos. Continue code improvement on other codes.**
- **FY2013-2015 Perform large-scale calculations for dark matter halos and galaxy formation. Start production runs for star- and planetary formation by FY 2014.**

Original members

- DM halo: Makino, Ishiyama
- Galaxy formation: Umemura, Okamoto, Saitoh, Hasegawa
- Star and planetary formation: Tomisaka, Kokubo, Ida
- Massive Black hole growth: Matsumoto, Ohsuga, Takahashi

(red: Hired by this project)

Our “real” goal

- **Make the best use of K computer for astrophysics**
- **Cover whatever subject outside subject 3**
- **Pick up promising new code/projects as much as we can**

Change of subprojects and members

New members/subprojects

- **Hotta: Large scale calculation of solar convective zone**
- **Kominami: Large scale calculation of planetary formation**
- **Namekata: Radiative MHD of AGN torus**
- **Nomura: Relativistic Radiative MHD of accretion disk around massive BH**

In the meantime...

- **Okamoto $\rightarrow$ Assistant Prof. at Hokkaido U.**
- **Saitoh $\rightarrow$ Associate Prof. at ELSI, TiTech.**
- **Hasegawa $\rightarrow$ Assistant Prof. at Nagoya U.**
- **Ishiyama $\rightarrow$ Associate Prof. at Chiba U.**
- **(Hotta $\rightarrow$ Assistant Prof. at Chiba U.)**

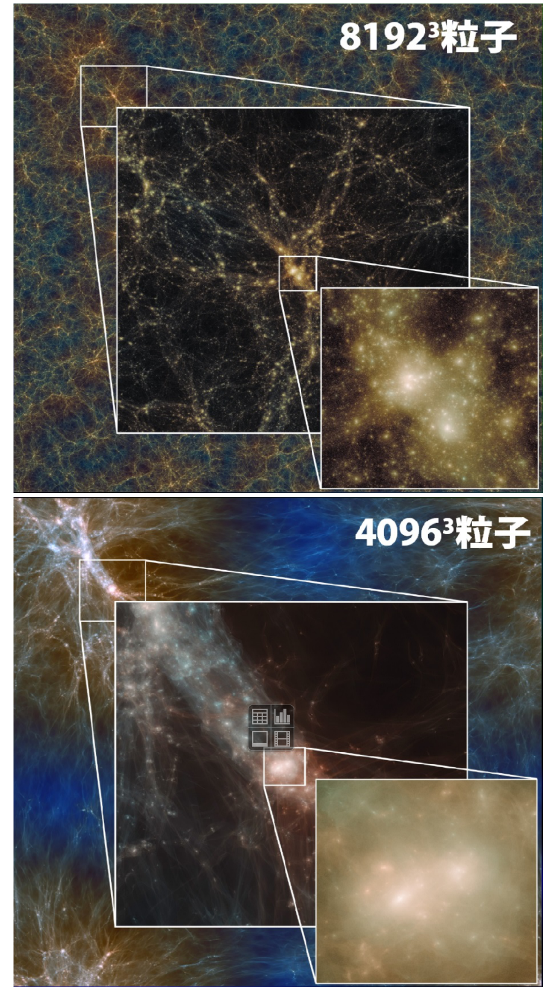
Final achievements (mostly as of early 2015)

- Dark matter halo (...)
- Galaxy formation (1st and 2nd talks, Parallel session 1A, Thursday, Posters P02, P07)
- Massive black hole growth (4th and 5th talks, Parallel session 1A, Thursday)
- Solar convective zone (2nd talk, Parallel session 3B, Friday)
- Planetary formation (4th talk, Parallel session 3B, Friday)

I'll summarize mostly the performance of codes and size of calculations. Full scientific results will be presented in individual talks and posters.

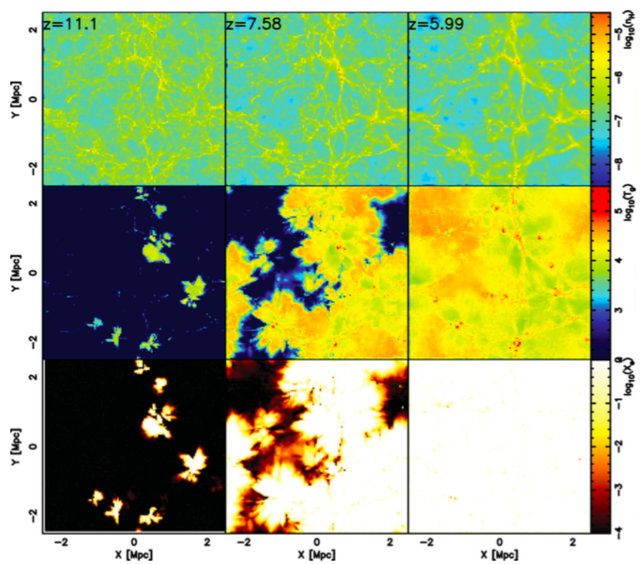
Dark Matter Halo Simulation

- Developed Parallel code “GreeM”. Achieved the calculation speed of 5.67PF (55% of the theoretical peak) on K computer.
- Turned out to be faster by a factor of 2.4 compared to a similar calculation on 20PF BG/Q.
- Awarded the 2012 ACM Gordon Bell Prize (Ishiyama, Nitadori and Makino).
- Performed a small-scale calculation with 4096^3 particles and a large-scale calculation with 8192^3 particles.



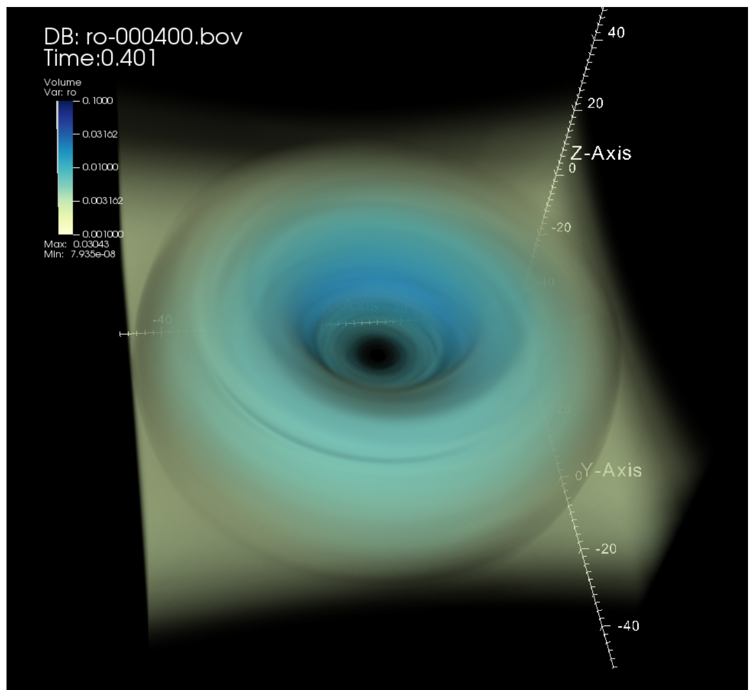
Galaxy formation

- Calculation code "START" for radiative hydrodynamics (including star formation) completed and optimized for K computer
- Calculations with 2×1024^3 particles finished (Susa, Hasegawa and Tominaga 2014, ApJ 792:32)
- 1st and 2nd talks, Parallel session 1A, Thursday, Posters P02, P07



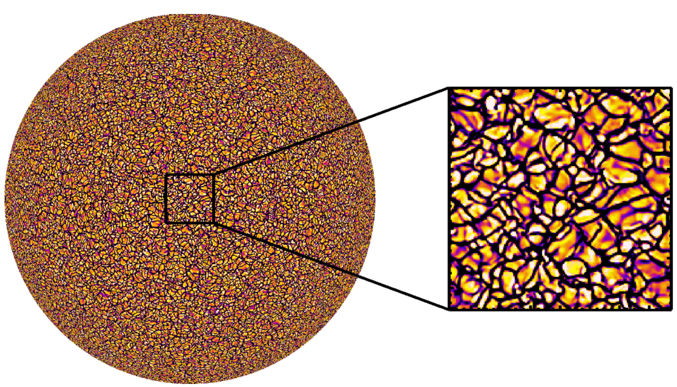
Massive black hole growth

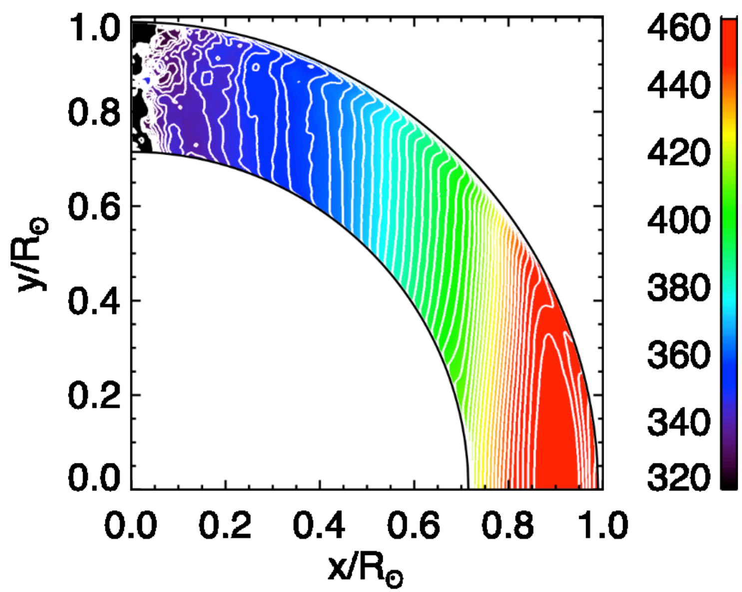
- 2D and 3D parallel Relativistic Resistive Radiation MHD code (R3MHD) developed
- Achieved the efficiency of $\sim 10\%$ on 1024 cores
- 4th and 5th talks, Parallel session 1A, Thursday



Solar convective zone

- New explicit method with reduced sound speed developed
- Calculation code "AMaTeRAS" developed
- Achieved the efficiency > 13% on 100k cores of K computer
- 2nd talk, Parallel session 3B, Friday





Planetary formation

- KninjaX, a New “two dimensional” parallelization code on K computer, developed
- Achieved the efficiency $\sim 15\%$ on 4096 nodes of K computer
- 4th talk, Parallel session 3B, Friday

Summary

- Original goals of "Subject 4" (not quite limited to "First Generation Objects") have been more or less achieved.
- In particular, the simulation of dark matter halos. achieved the efficiency of 55% on near full nodes of K computer, and awarded 2012 ACM Gordon Bell prize.
- Other calculation codes for galaxy formation, massive black hole growth, solar convection, planetary formation have achieved the efficiency of 10% or more, for number of cores between 1K and 100K.
- Impressive computational performance resulted in impressive scientific results, as you'll learn in the rest of this week.