Radiative Magnetohydrodynamic Accretion Flows and Jets

Yoshiaki Kato (Univ. of Tsukuba)

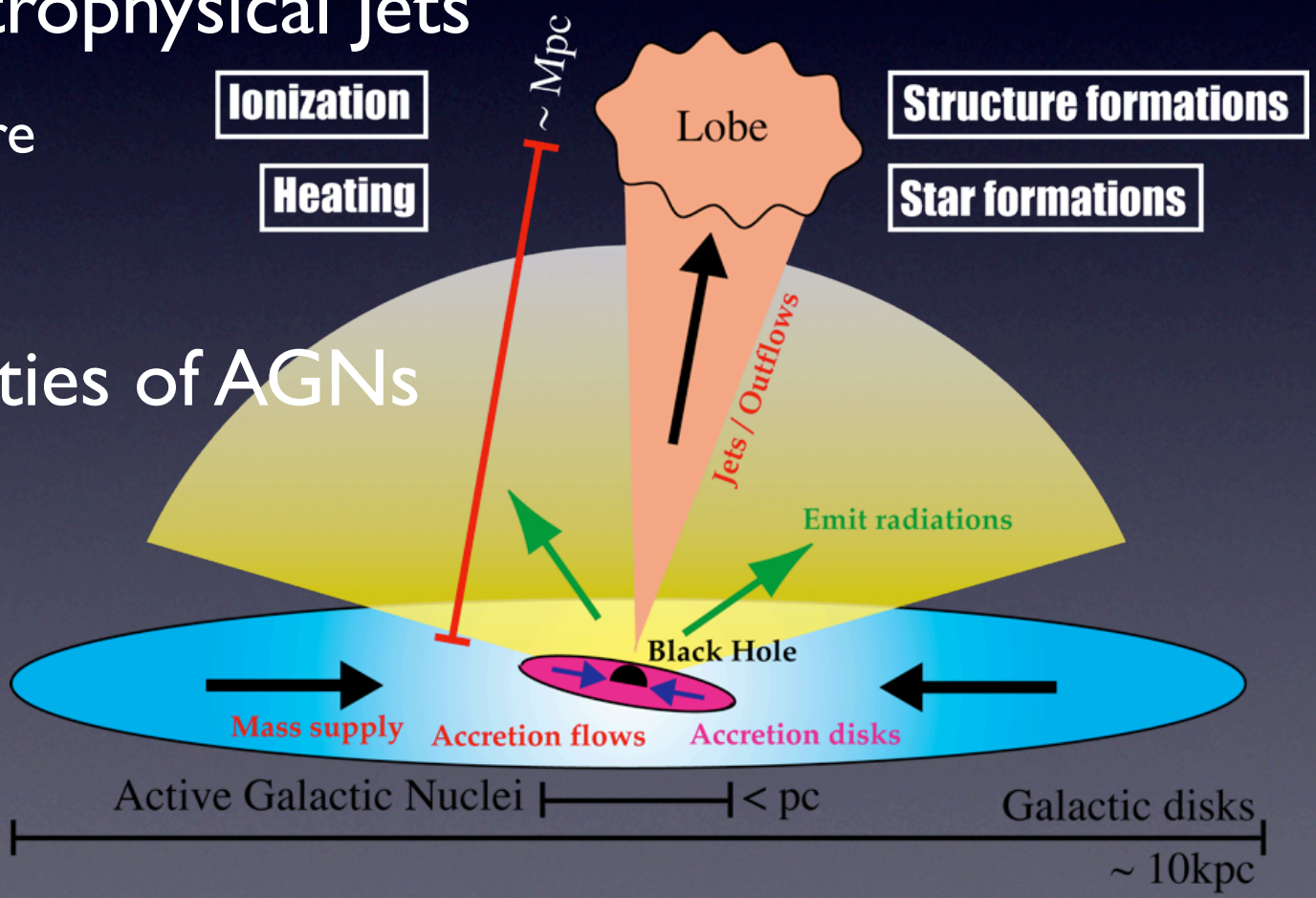
Ryoji Matsumoto (Chiba Univ.)
Shin Mineshige (Kyoto Univ.)
Kazunari Shibata (Kyoto Univ.)
Ken Ohsuga (RIKEN)
Masayuki Umemura (Univ. Tsukuba)

Contents of my talk

- Non-Radiative MHD Accretion Flows and Jets
  - Launching mechanism of Jets in MHD Accretion Flows
  - Quasi-Periodic Oscillations in MHD Accretion Flows
- Radiation Transfer in MHD accretion flows
  - Examine the MHD accretion flow model by comparing the emergent spectra with the observed spectra in our galactic center source, SgrA*.

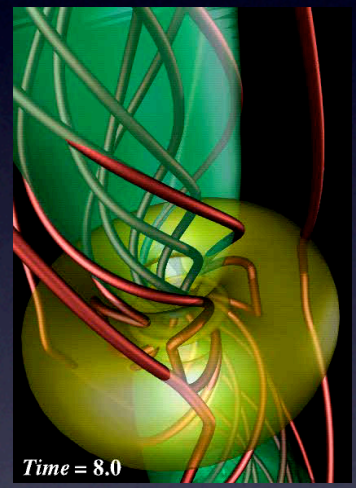
Why we study accretion flows and jets?

- Formation and Evolution of Supermassive Black Holes
- Formation of Astrophysical Jets
  - Large-scale structure
  - Heating of IGM
- Radiative properties of AGNs
  - Variability
  - Ionization of IGM
  - Heating of IGM



Launching Mechanism of Jets in MHD Accretion Flows

- Caveats in previous studies on launching jets:
  - Large-scale strong magnetic field lines permeating accretion disks
  - Origin of such magnetic field lines is out of concern



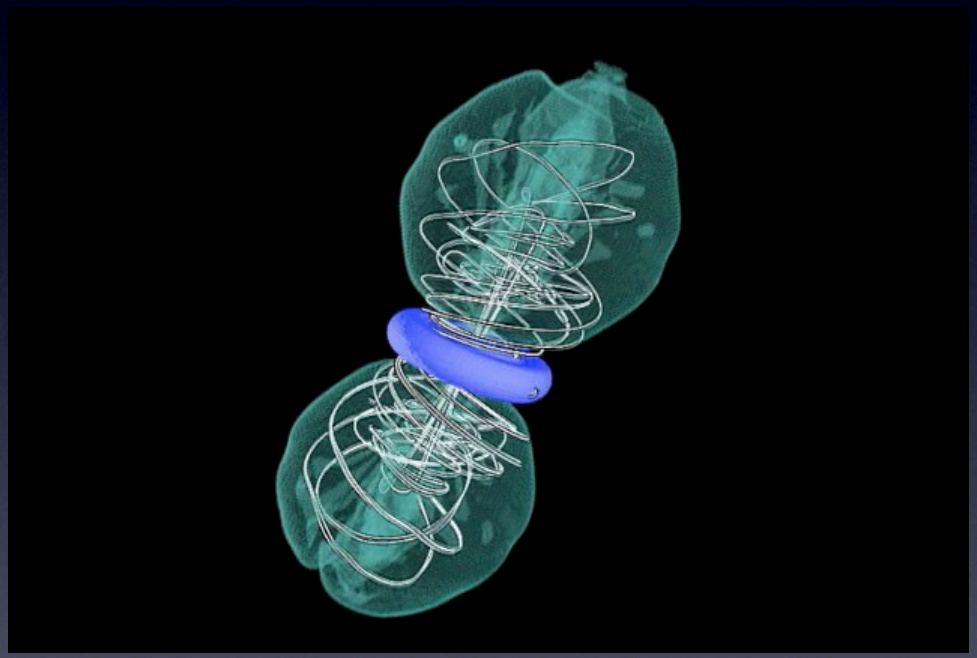
- Key questions:
  - Can magnetic fields associated with stars and accretion disks produce jets?
  - If so, how?

Magnetic-Tower Jets

(YK, Hayashi, Matsumoto 2004; YK, Mineshige, Shibata 2004)

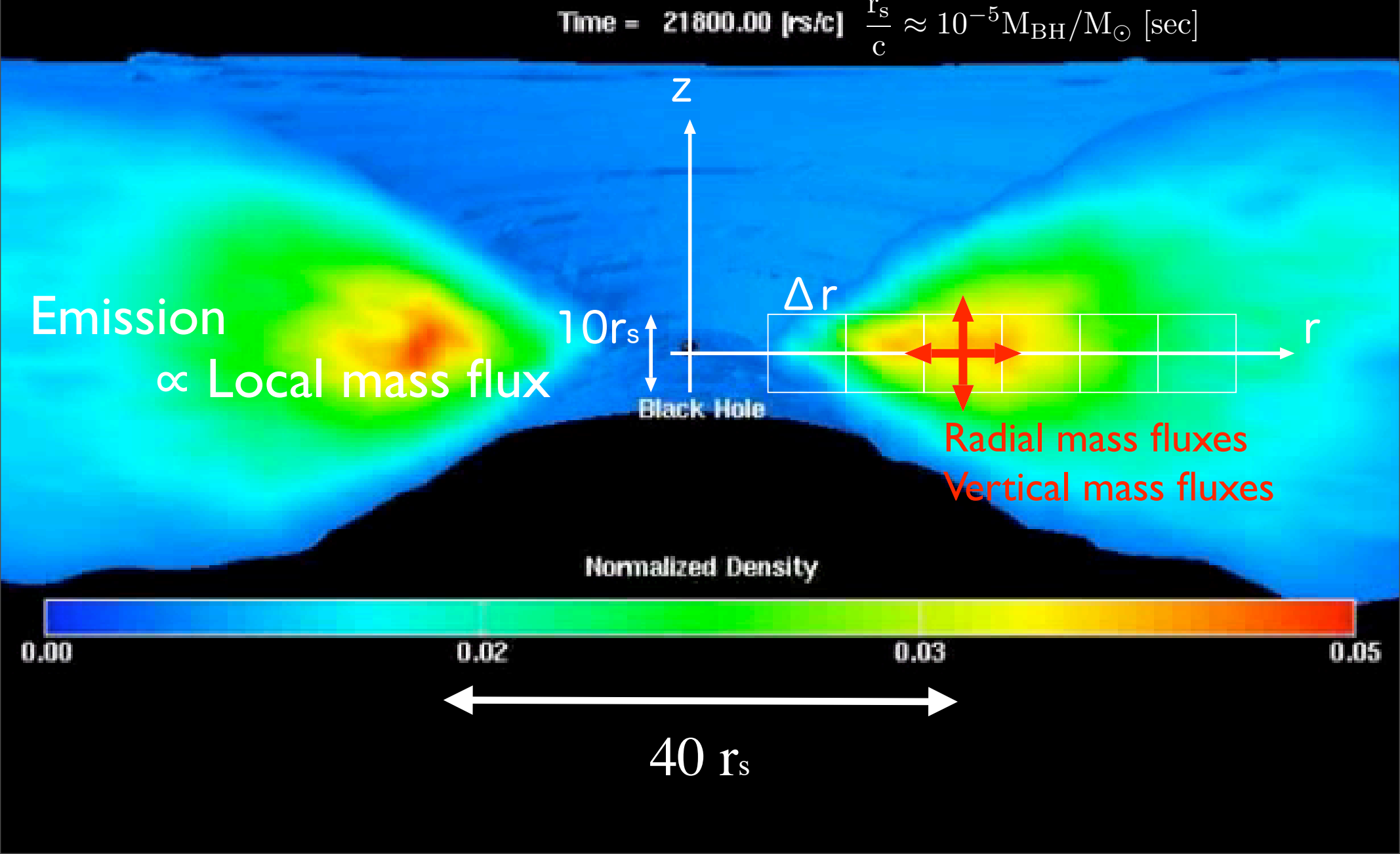
Magnetosphere of Neutron Stars

Magnetized Accretion Flows around Black Holes



The magnetic tower jet solution is an universal mechanism which can produce jets in dynamo-active accretion disks!!!

Quasi-Periodic Oscillations (QPOs) in MHD accretion flows (YK 2004)

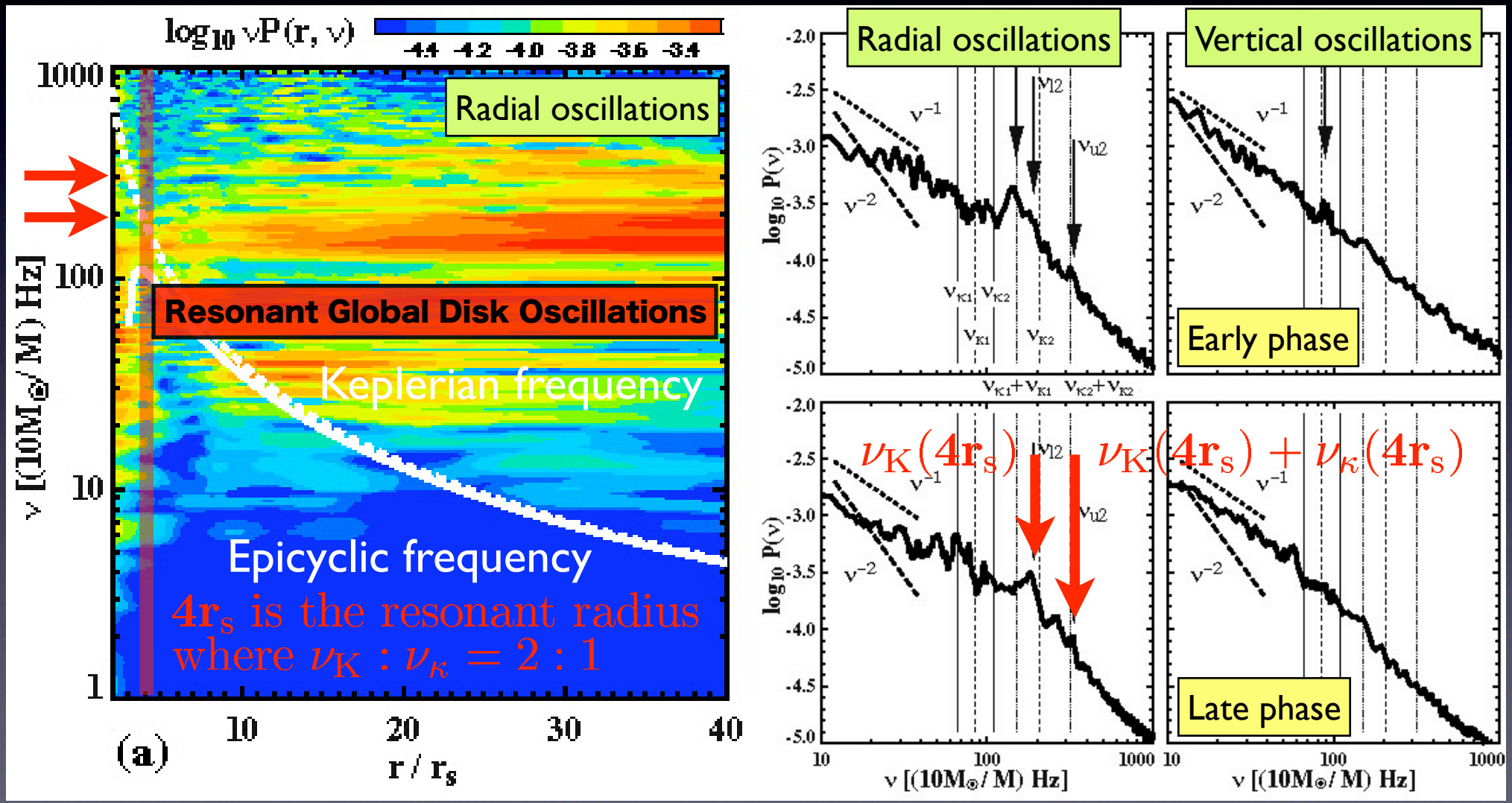


Twin Quasi-Periodic Oscillations in MHD Accretion Flows

(YK 2004)

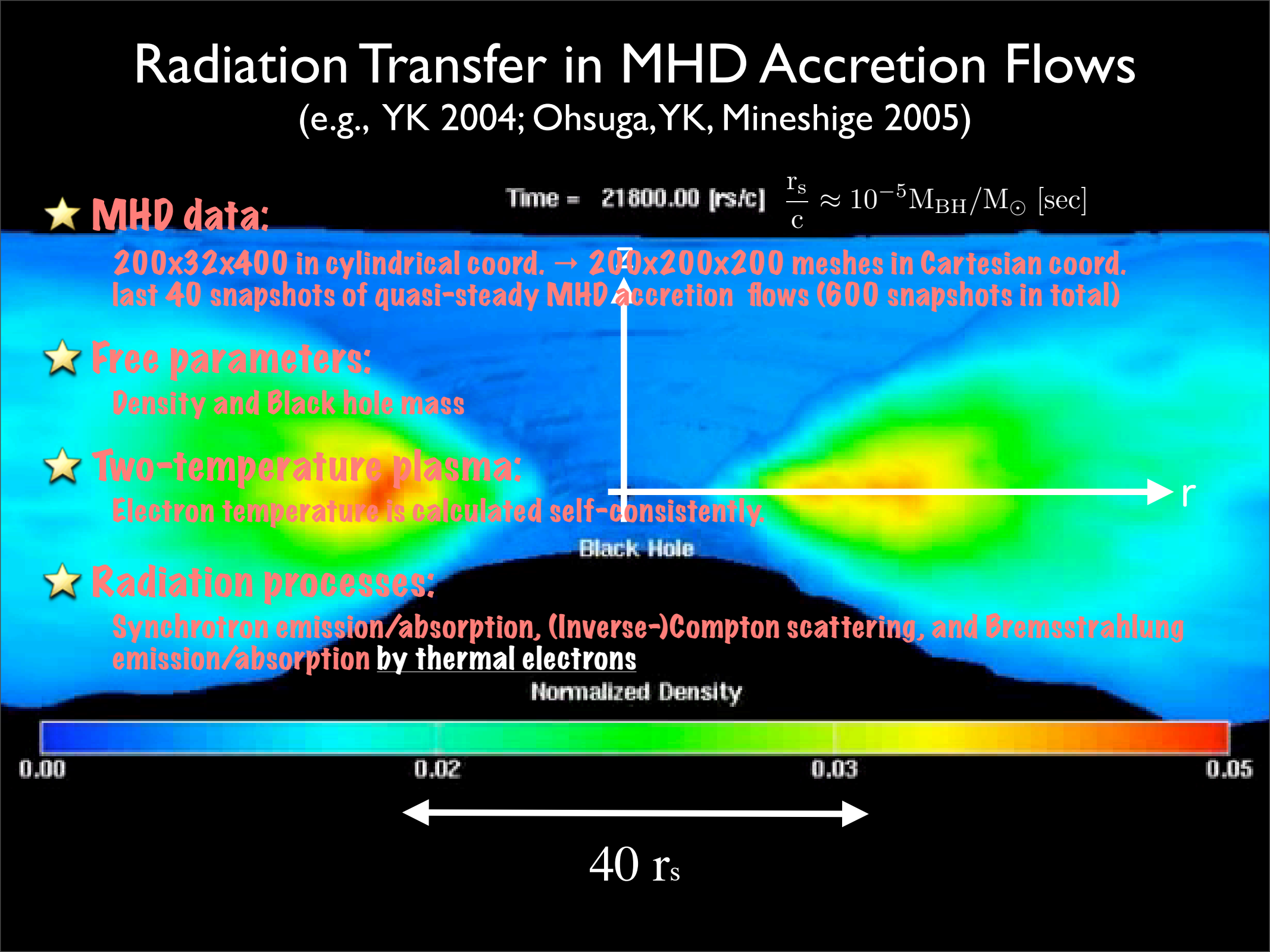
PSD as a function of radius

PSD integrated over the radius



Radiation Transfer in MHD Accretion Flows

(e.g., YK 2004; Ohsuga, YK, Mineshige 2005)



★ **MHD data:**

200x32x400 in cylindrical coord. → 200x200x200 meshes in Cartesian coord.
last 40 snapshots of quasi-steady MHD accretion flows (600 snapshots in total)

★ **Free parameters:**

Density and Black hole mass

★ **Two-temperature plasma:**

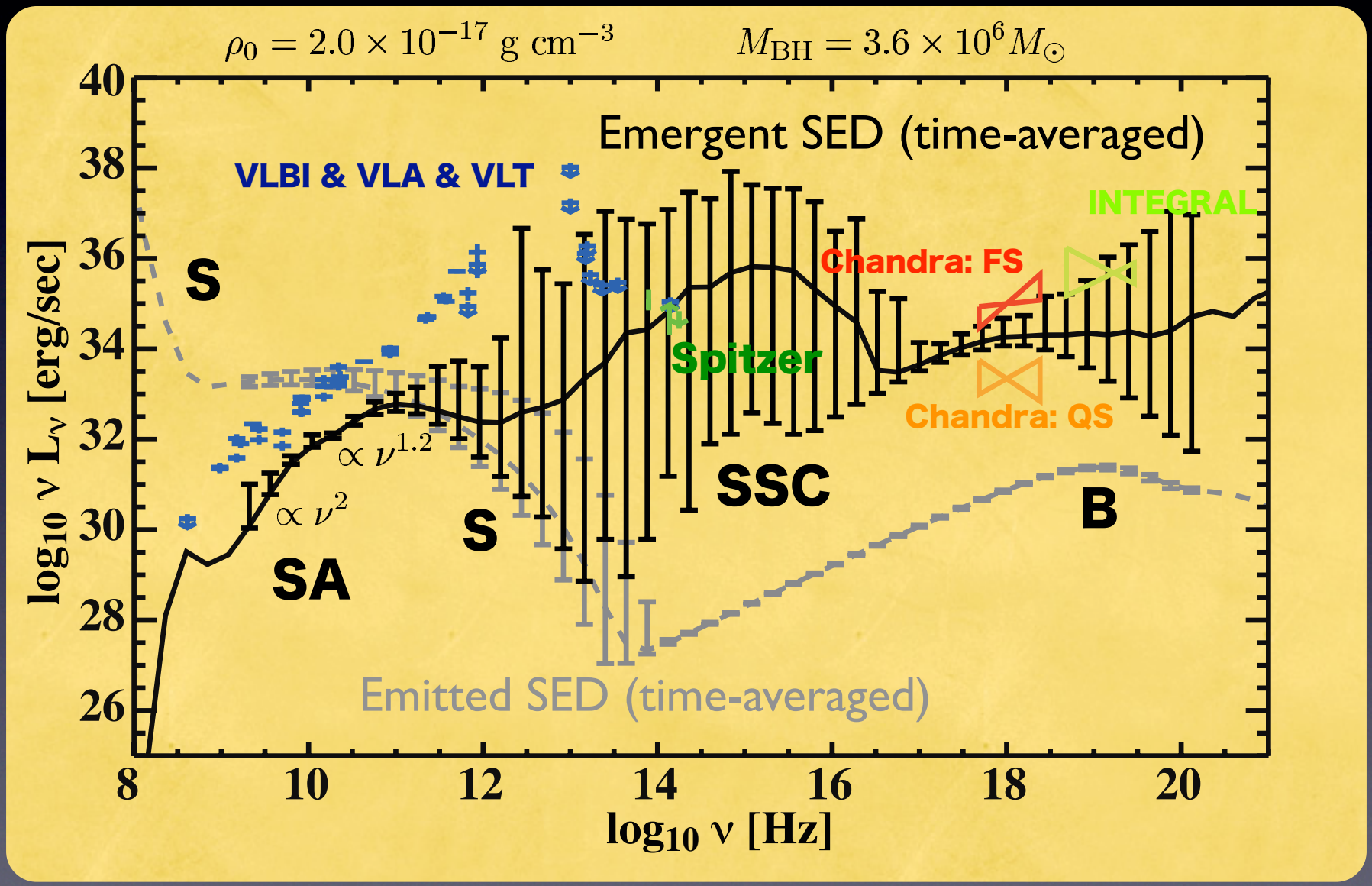
Electron temperature is calculated self-consistently.

★ **Radiation processes:**

Synchrotron emission/absorption, (Inverse-)Compton scattering, and Bremsstrahlung emission/absorption by thermal electrons

Emergent SED of MHD Accretion Flows

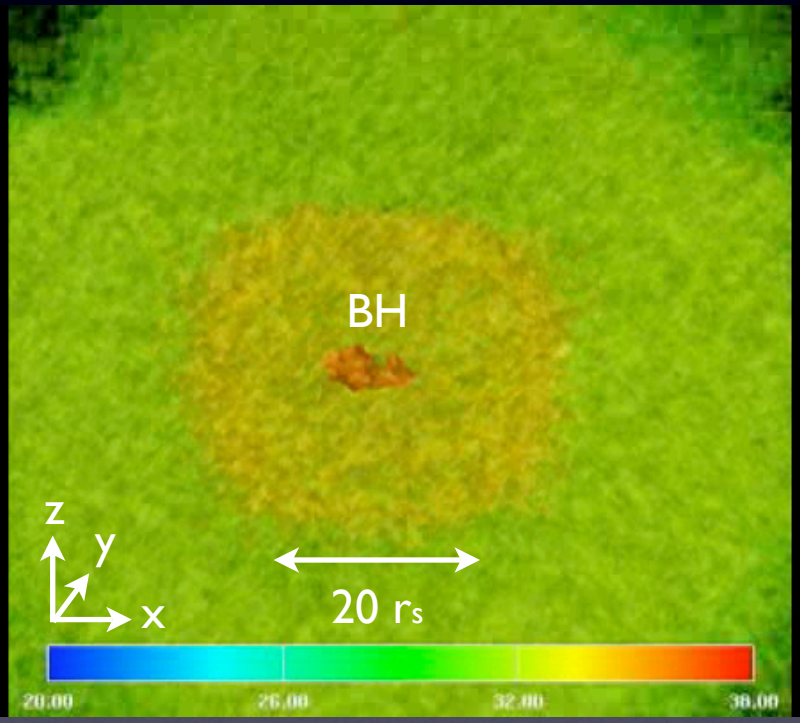
(YK, Ohsuga, Umemura, Mineshige in prep.)



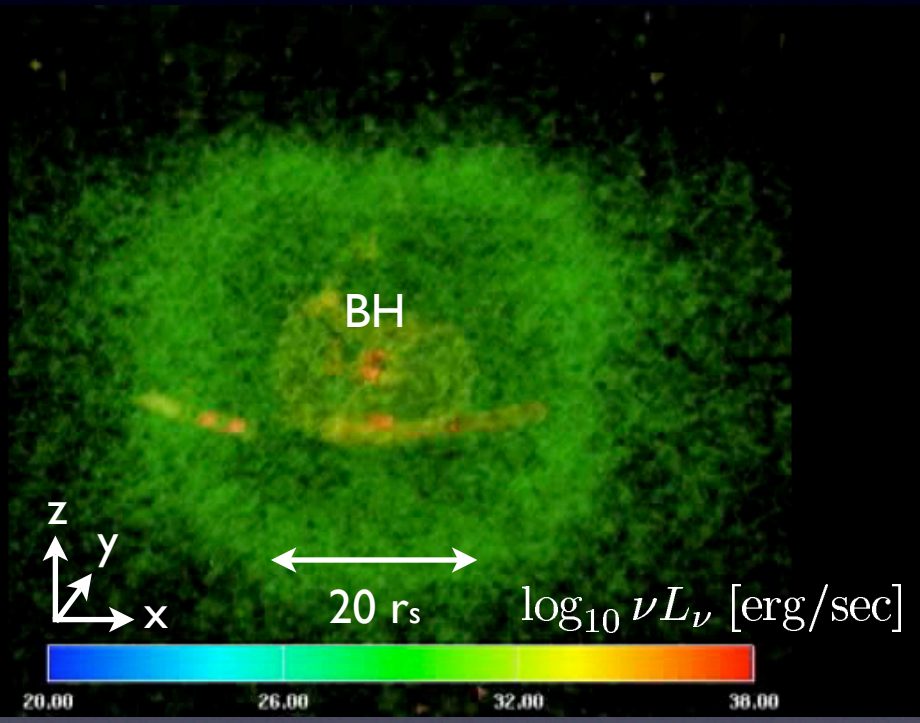
Spatial Distribution of the Power of Escaping Photons

(YK, Ohsuga, Umemura, Mineshige in prep.)

One-temperature plasma model



Two-temperature plasma model



Plasma model is crucial not only for evaluating emission region but also for time variability

Summary

- Magnetic fields associated with stars and disks can produce jets:
  - Magnetic loops connecting between differentially rotating objects deform themselves into a magnetic-tower,
  - The magnetic-tower can drive jets and outflows.
- Resonant disk oscillations can be excited in MHD accretion flows that can account for quasi-periodic X-ray brightness oscillations in X-ray binaries including micro-quasars:
  - QPOs trace the metric (the mass and the spin) of black holes.
- Emergent SEDs can explain the observed SED in SgrA*:
  - Radiation transfer is inevitable for evaluating electron temperature (e.g., two-temperature plasma),
  - Radiations in MHD flows can account for variable emissions in recent NIR and X-ray observations in SgrA*.