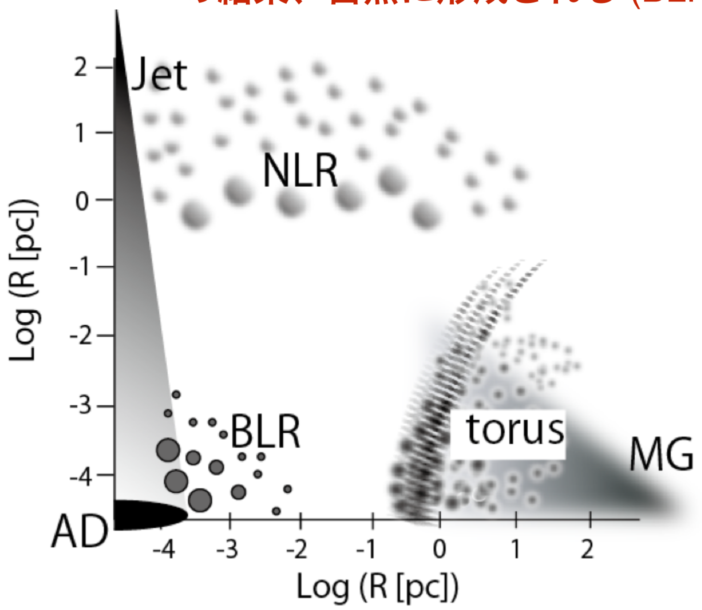
超巨大BH研究推進連絡会第２回WS@筑波大　11/2-3/2014

輻射フィードバック影響下のAGN近傍星間ガスの力学・化学構造

"obscuring structure" はAGNからのradiation feedbackの結果、自然に形成される (BLRやNLRも？)



和田桂一
鹿児島大学

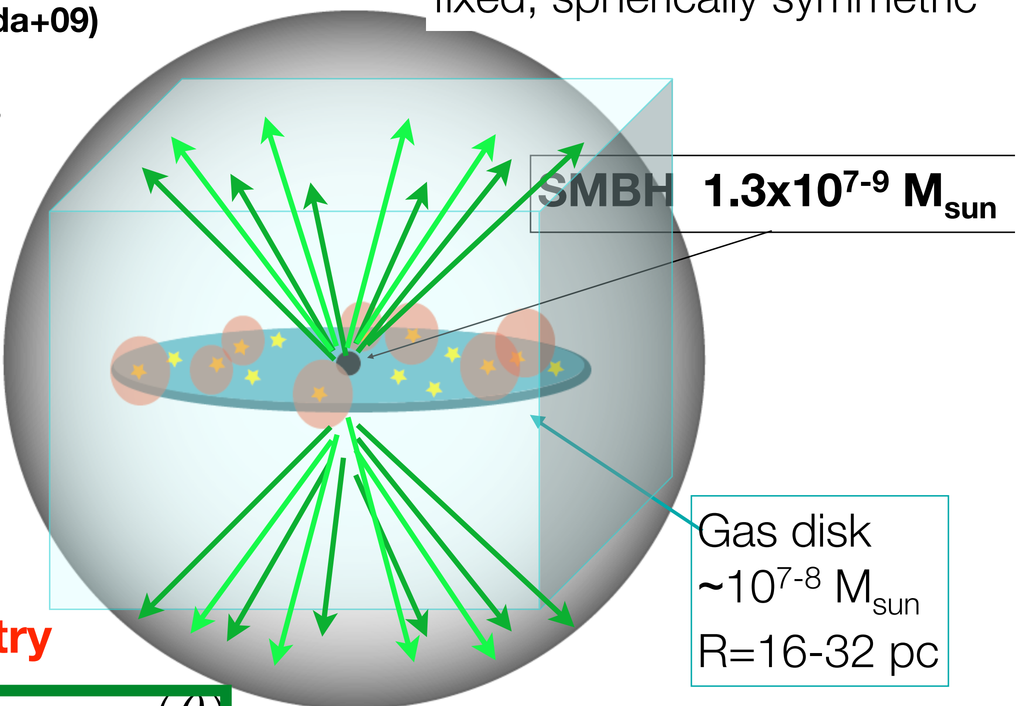
Marc Schartmann (MPE)
Rowin Meijerink (Leiden)

3-D Radiative Hydrodynamics of a gas disk around a SMBH

Code: RHD.*(Wada12) ,
based on HD.* (Wada+09)

Stellar/DM potential:
fixed, spherically symmetric

***Uniform grid 256^3**
***Ray tracing**
(256^3 rays),



- **Self-gravity**
- **Radiative cooling**
- **X-ray heating**
- **uniform FUV**
- **SNe feedback**
- **New! chemistry**

$$\boxed{L_{AGN}(\theta) \propto \cos(\theta)}$$

任意の方向

Wada (2012)

outflow

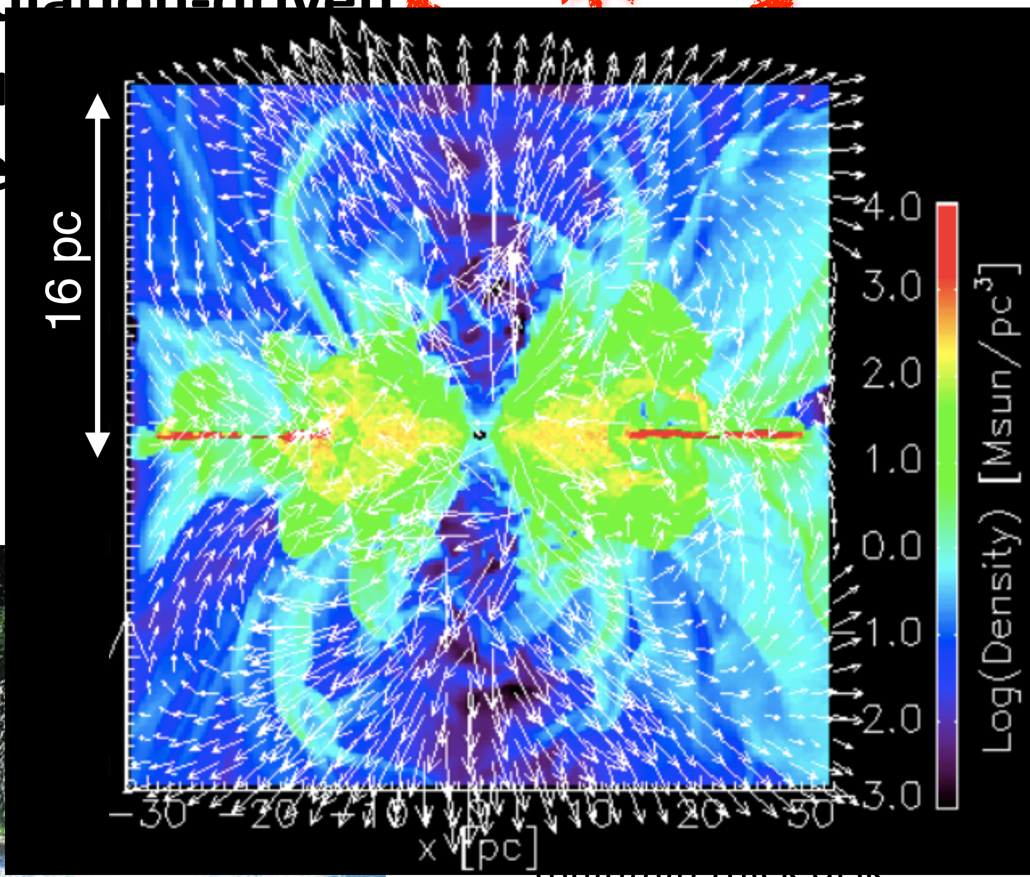
Radiation-driven

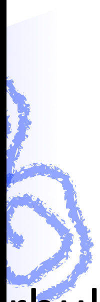
fou

the

flow

rbulence





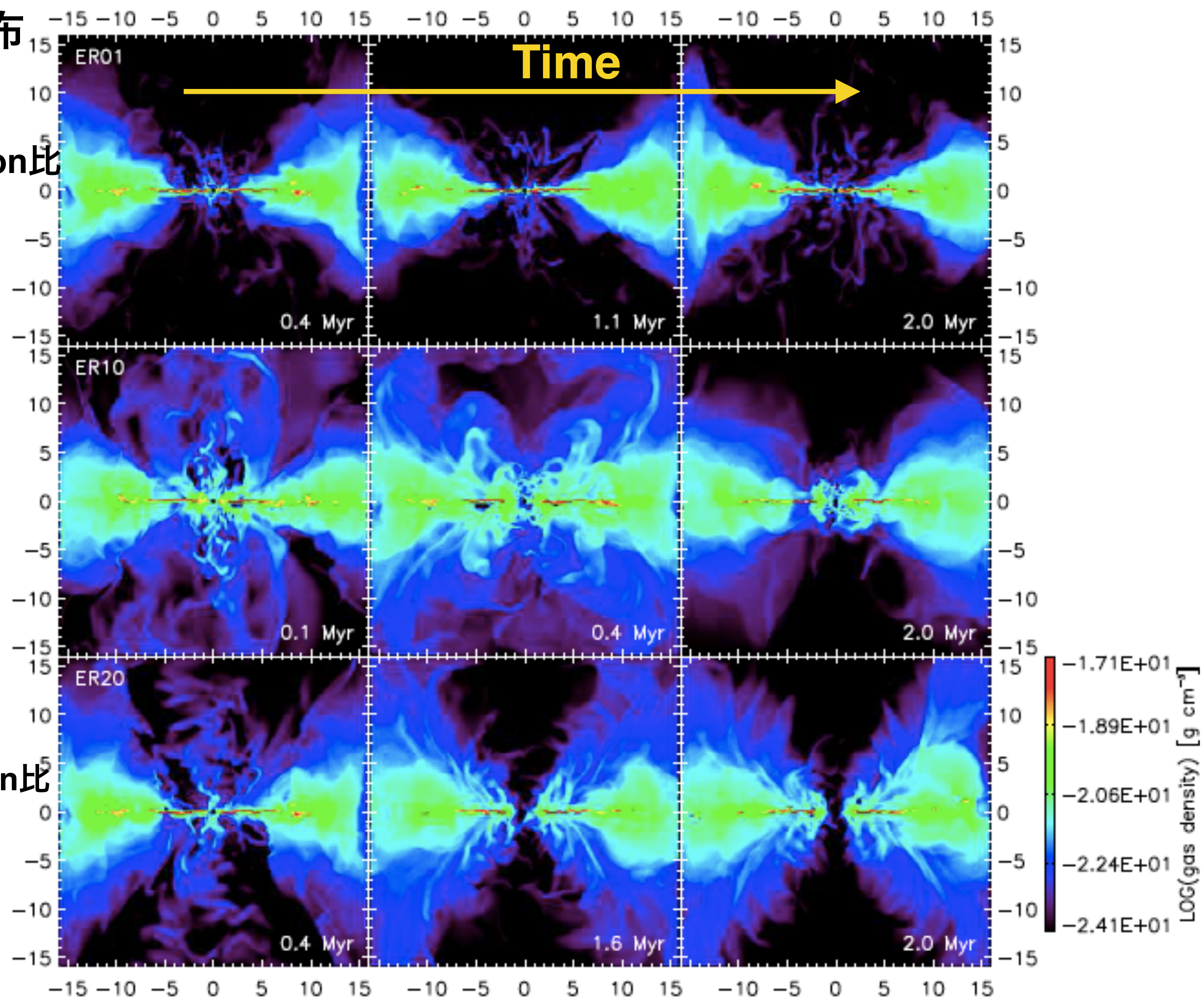
maintain thick disk

3

密度分布

Eddington比小

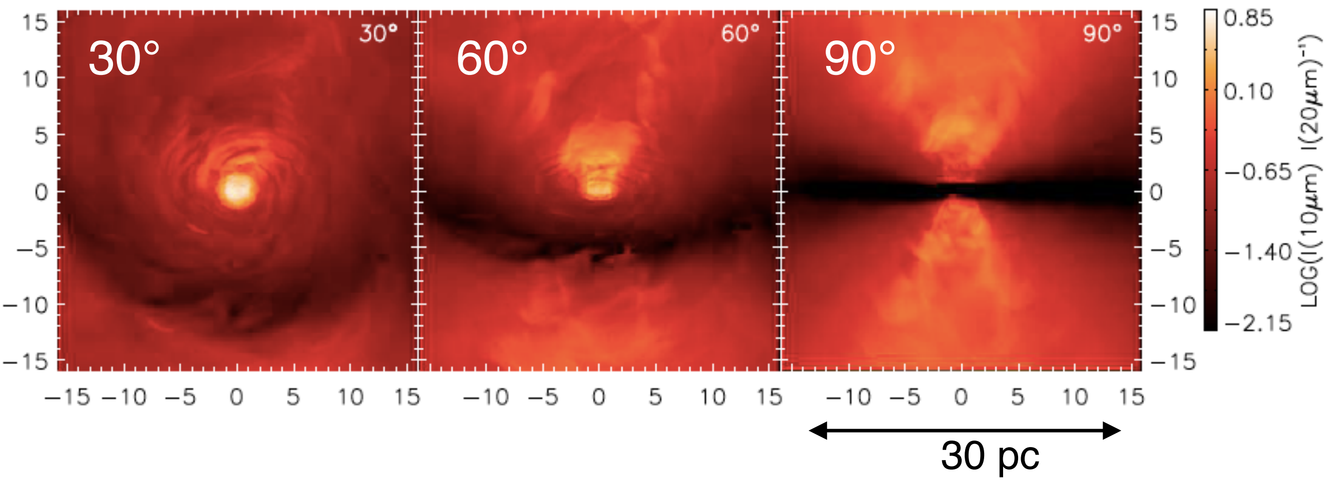
Eddington比大



Post-process calculations using 3D Monte Carlo method

→ **thin disk (cold dust) + thick disk (warm dust) + biconical outflows (hot dust)**

10μm/20μm ratio ⇒ temp. of dusty gas



extended dust emission along the rotational axis is found. → classicalなtorus modelでは予想されていない

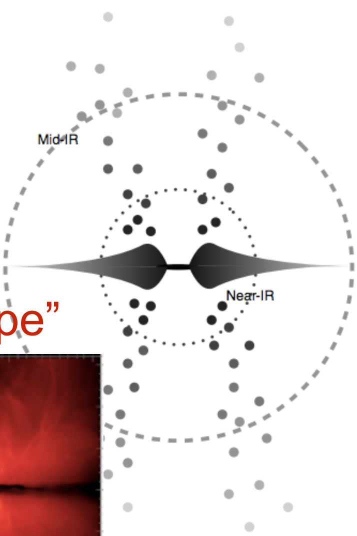
Schartmann, Wada, Prieto, Burkert, & Tristram (2014)

The Astrophysical Journal, 755:149 (16pp), 2012 August 20 doi:10.1088/0004-637X/755/2/149

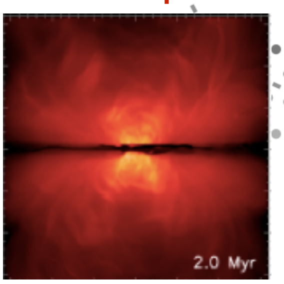
PARSEC-SCALE DUST EMISSION FROM THE POLAR REGION IN THE TYPE 2 NUCLEUS OF NGC 424

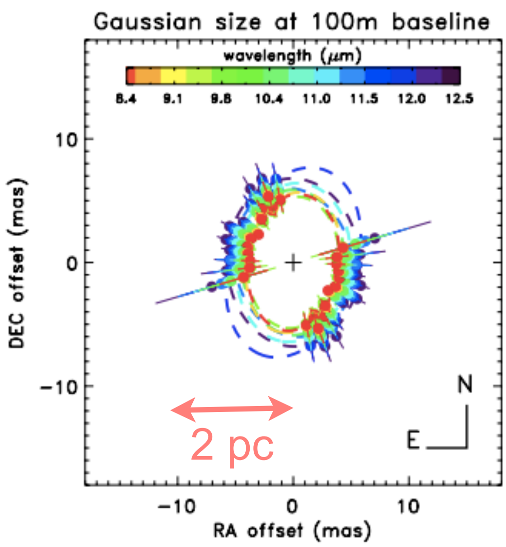
S. F. Hönig[1], M. Kishimoto[2], R. Antonucci[1], A. Marconi[3], M. A. Prieto[4], K. Tristram[2], and G. Weigelt[2]

- VLTI/MIDI による干渉計観測（回転軸方向に hot dustがあるらしい）



"X-shape"

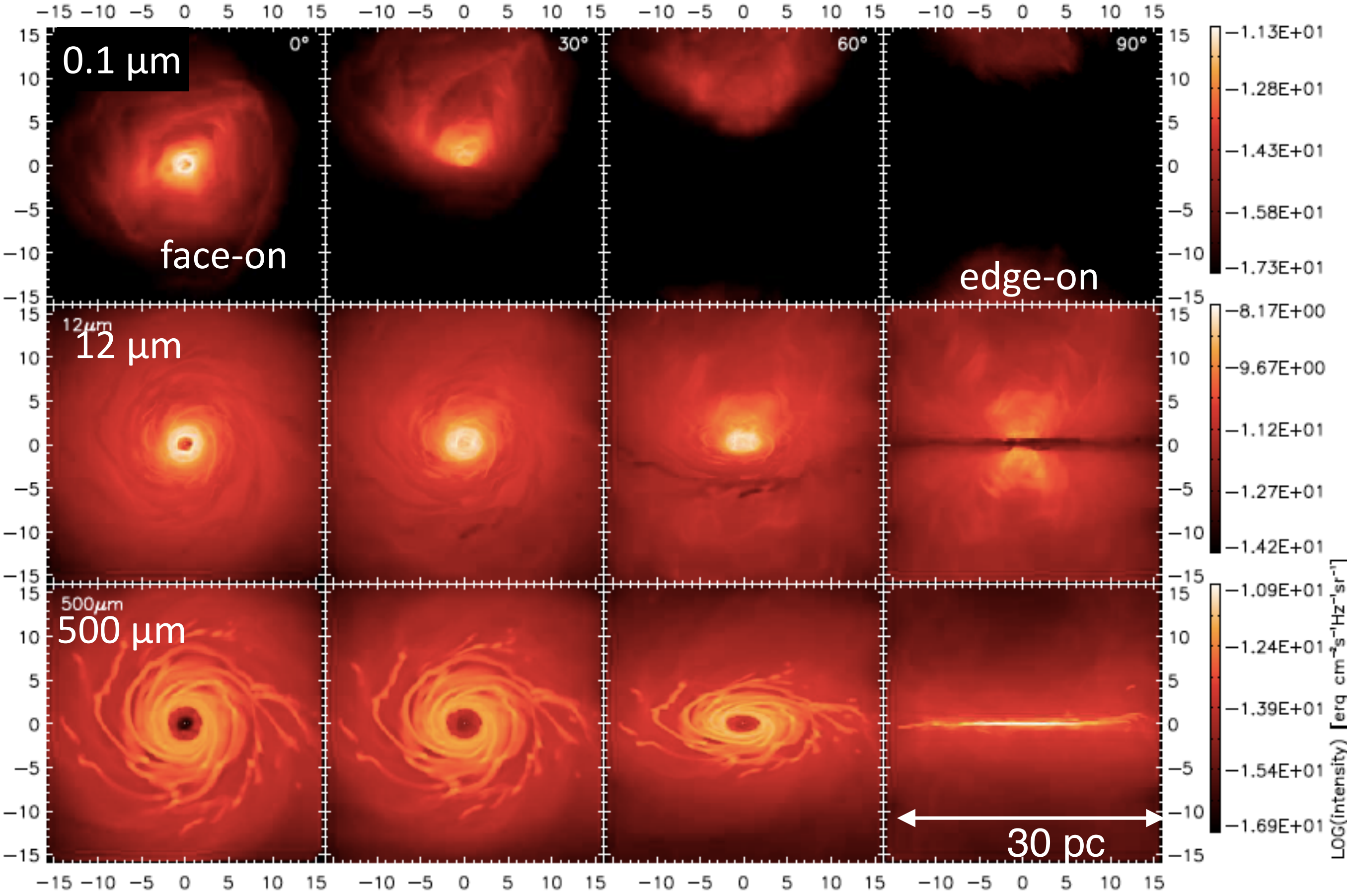




Larger mid-IR emission for longer wavelength

ISM around AGN in different λ

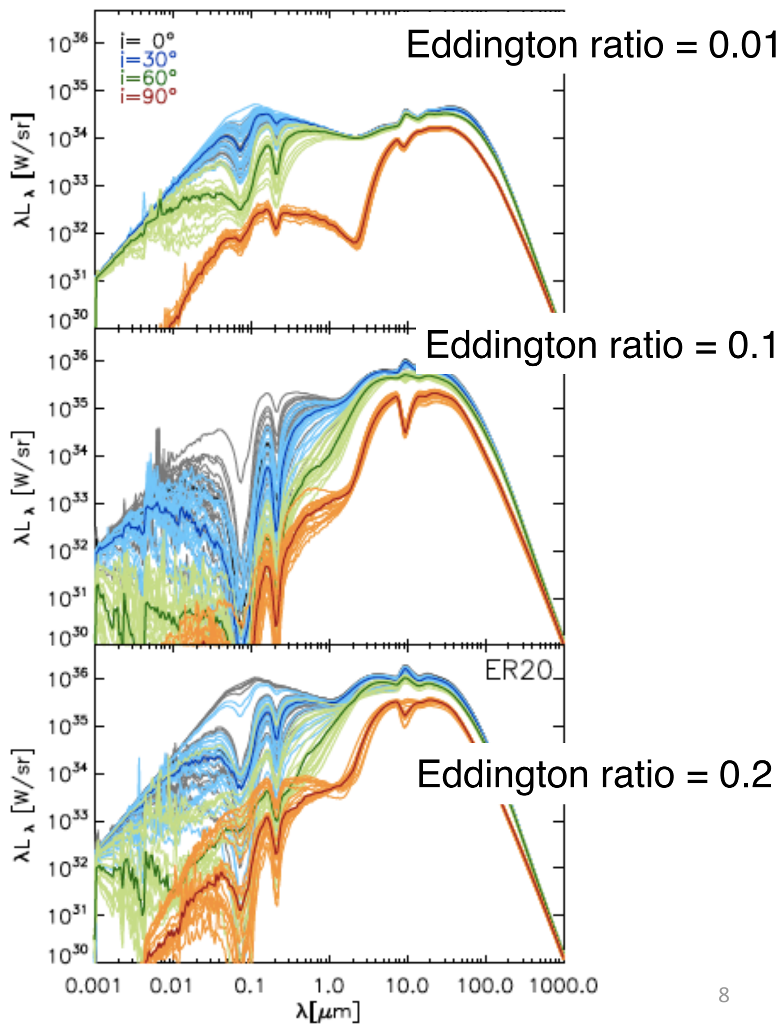
Schartmann+ 2014



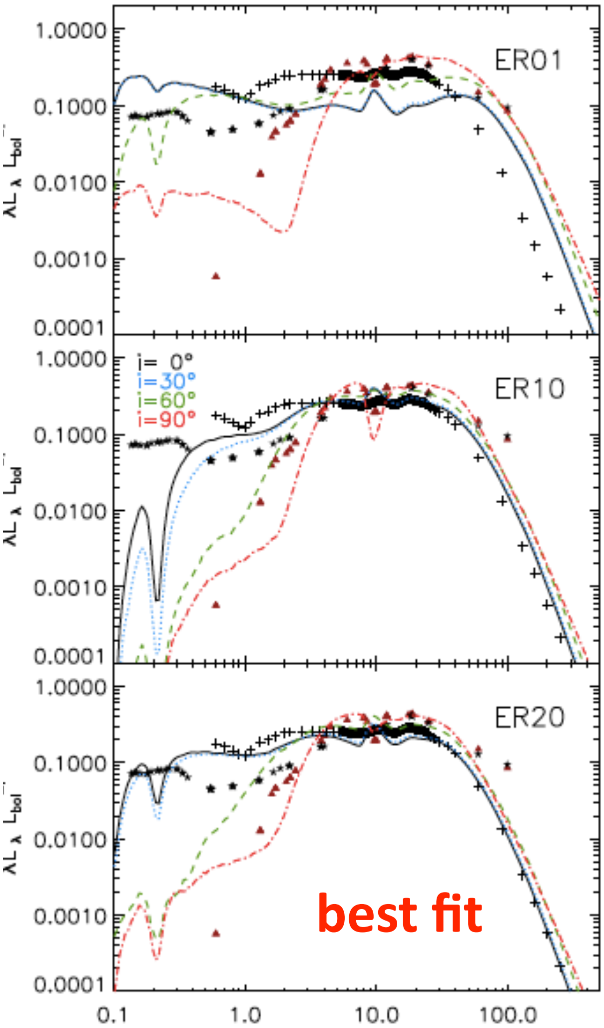
SEDs depend on Eddington ratio, viewing angle, & time

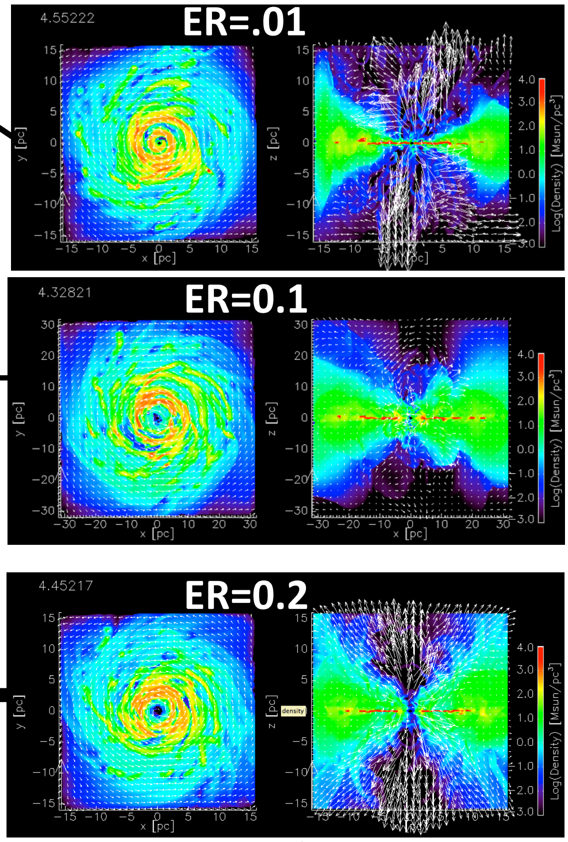
λ > 1.0 μm ではSEDの時間変動 (~ 0.1Myr)は小さい。

λ < 1 μm の時間変動 (~ 1-2桁）は、bipolar outflow (scattered light)起源



SEDを説明するためにradiation feedback必要



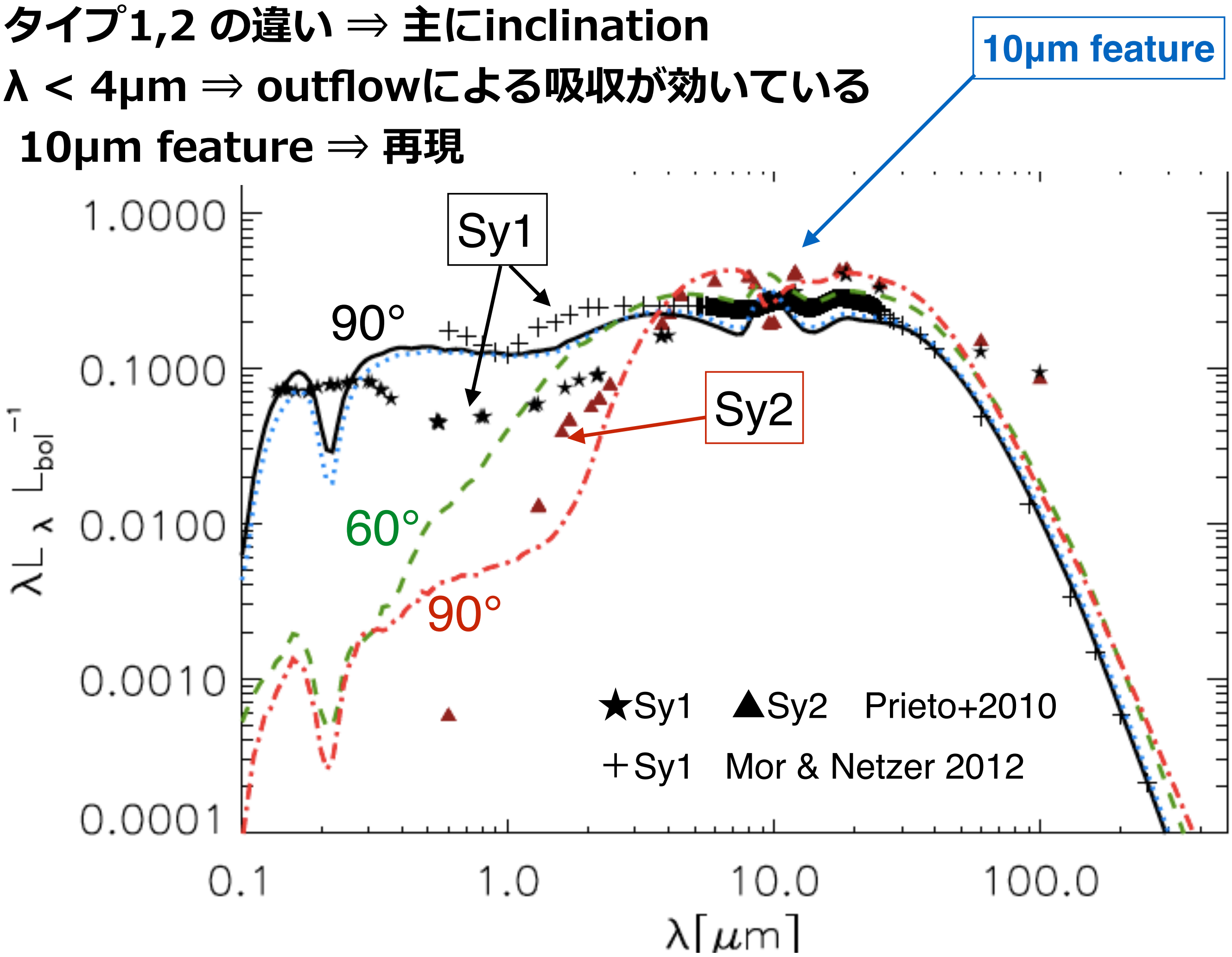


Schartmann+ 2014

タイプ1,2 の違い ⇒ 主にinclination

λ < 4μm ⇒ outflowによる吸収が効いている

10μm feature ⇒ 再現



New!

Non-equilibrium XDR chemistry under the AGN radiation (with R. Meijerink)

H, H2, H+, H2+, H3+, H-, e-, O, O+, O2, O2+, O2H+, OH, OH+, H2O, H2O+, H3O+, C, C+, CO, Na, Na+, He, He+

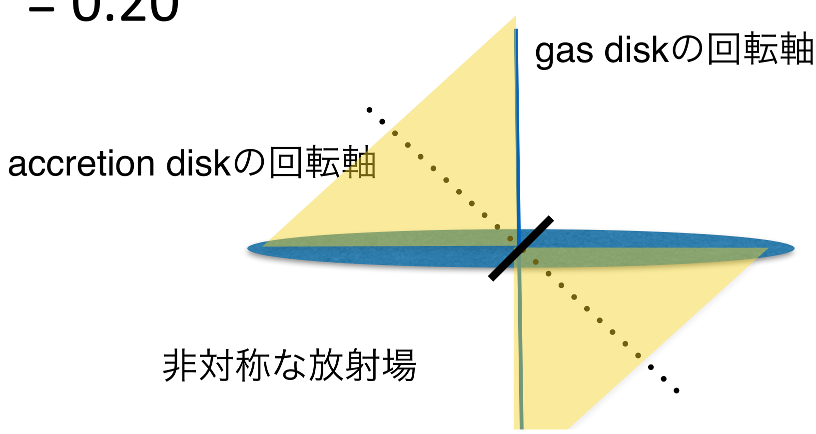
- chemistry is solved in all radiation-hydrodynamic grid cells (128^3 cells in test calculations) + **advection**
- radiation source = AGN+ FUV (constant G0)
- SNe feedback (cf. Wada, Papadopoulos, Spaans 09)

Motivation:
CO, HCN, OH etc. outflows (v >100 km/s, dM/dt~10 Msun/yr) observed in AGNs/ULIRGs (e.g. NGC 1433: Combes+2013, NGC1377: Aalto+2012, Mrk231: Gonzalez-Alfonso+2013) are reproduced?

AGNで molecular outflowを作れるか？

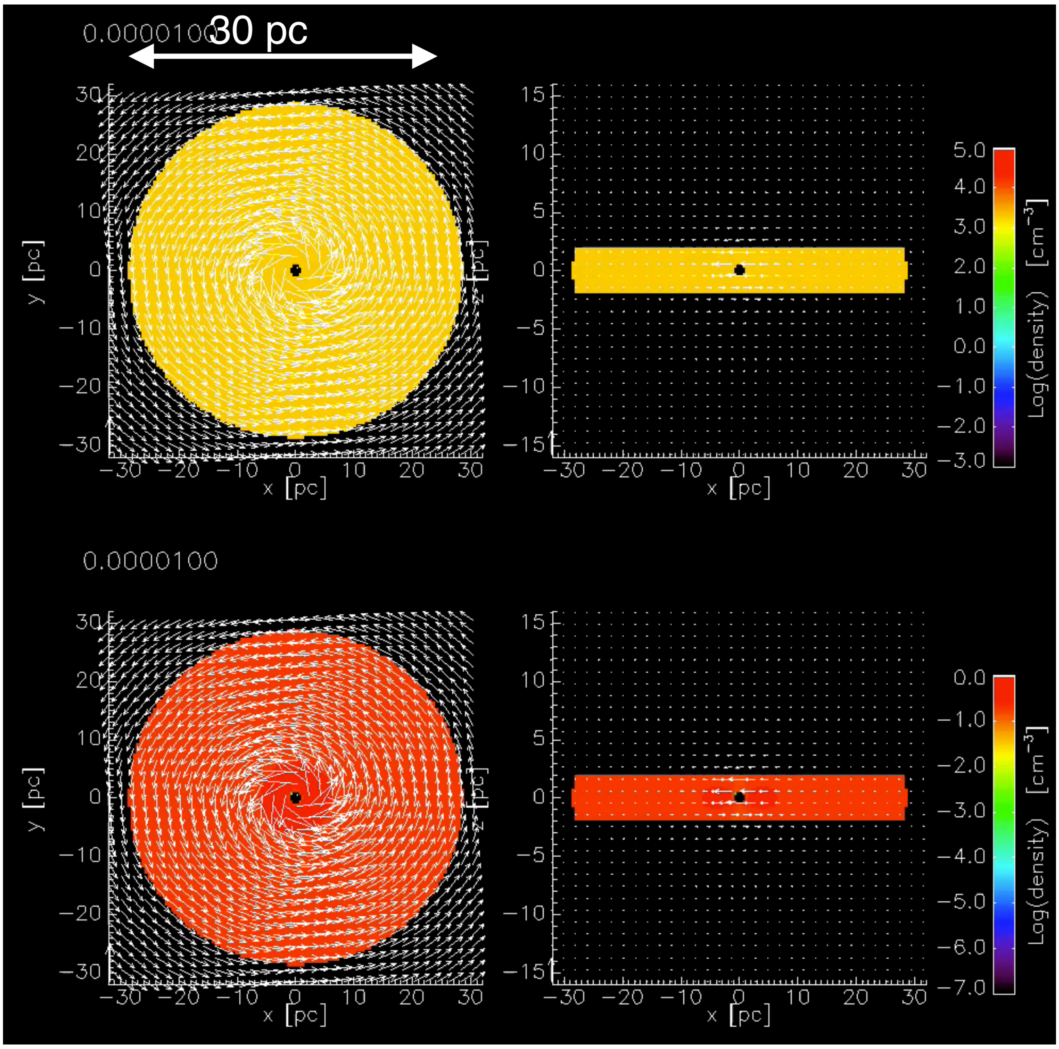
preliminary results

- box size: 32 pc^3 (resolution: 0.25 pc)
- M_{BH} = 1.3 $x10^8$ Msun
- M_{gas} = 10^7 Msun
- L_{AGN}/L_{Edd} = 0.20



H_2

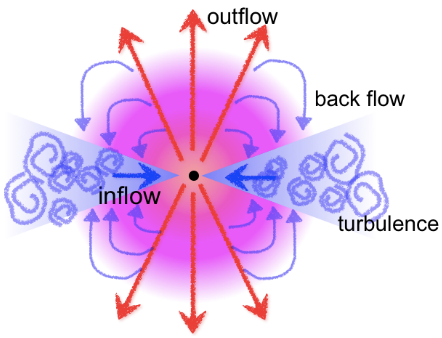
Obscured AGN の構造？



OH

OH ouflowはほとんど吹かない

まとめ



Wada 2012

1) （少なくとも中〜低光度）AGNには非定常、非一様な “radiation-driven fountain”が形成され、”トーラス”的に中心核を遮蔽する。

2）”トーラス” = thin disk, thick disk, bipolar outflowsの3成分、type-1, 2 SEDを再現

Schartmann+2014

chemo-radiation hydrodynamics

*3） ”molecular outflows” はAGN feedback*で作れるか？ …難しい. ***SNe feedbackが必要?***

Meijerink &KW in prep.