Cloud formation and acceleration in AGN

Governing equations
These are the basic equations of multiphase gas dynamics:
\[
\frac{\partial \rho}{\partial \tau} + \nabla \cdot (\rho \mathbf{v}) = 0, \\
\frac{\partial (\rho \mathbf{v})}{\partial \tau} + \nabla \cdot (\rho \mathbf{v} \mathbf{v} + P \mathbf{I}) = -\rho \mathbf{a} - q + \mathbf{f}_{\text{rad.}} + \mathbf{f}_{\text{drag}}. \\
\frac{\partial E}{\partial \tau} + \nabla \cdot \left( (E + \rho P) \mathbf{v} - \rho \mathbf{u} \right) = -\mathbf{q} \cdot \mathbf{v} + \mathbf{f}_{\text{rad.}} \cdot \mathbf{v},
\]
where the radiation force is given by (see Proga & Waters 2015),
\[
f_{\text{rad.}} = \frac{\rho F_{\text{rad.}}}{c^2} \left[ 1 + f(v_{\infty}) + \sigma T C_{\text{eff}} \right].
\]

Modeling approach:
Local box simulations of UV and X-ray irradiated plasma

Basic principle
Saturation of thermal instability (TI) is a cloud formation process, but it also naturally leads to cloud acceleration (Proga & Waters 2015).

Synthetic UV/X-ray absorption lines from 1st principles

1. Observed SEDs
2. Photoionization calculations
3. Synthetic absorption lines
4. Hydrodynamical simulations

Here we show the obscured and unobscured SEDs for NGC 5548 obtained by Mehdipour et al. (2015)

Using a post-processing routine that again interfaces with XSTAR to compute the opacity of a given ion at every grid zone, we compute absorption line profiles of common doublet lines using the techniques developed by Waters et al. (2017).

Using Athena++, we performed simulations similar to Proga & Waters (2015) but for the SEDs above using a fully self-consistent pipeline.

References
5. Waters, Proga, Dannen, & Kallman, Synthetic Absorption Lines for a Clumpy Medium: a spectral signature for cloud acceleration in AGN?, 2017 MNRAS, 467, 3160

These calculations were performed on the Institutional Computing clusters at Los Alamos National Lab...