Absorption Measure Distribution in Active Galactic Nuclei

T. P. Adhikari
Nicolaus Copernicus Astronomical Center, Warsaw, Poland
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Collaborators
Agata Różańska, Bozena Czerny, Krzysztof Hryniewicz

AGN Winds on the Georgia Coast, 25-29 June 2017
Outline

• Absorption Measure Distribution (AMD) in AGNs: definition and observational motivation

• Photoionisation modelling of AMD

• Results from our modelling using TITAN (Dumont+ 2000) photoionisation code

• Summary
Absorption measure distribution (AMD) in AGNs: from observations

Holczer+ 2007

- AMD requires $\xi$ and $N_H$

$$\text{AMD} = dN_H / d(\log \xi), \quad \xi = L / nR^2$$

$$N_H = \int \text{AMD} \, d(\log \xi).$$

- $N_{\text{ion}}$ is derived by fitting Gaussian profiles to the X-ray absorption lines in the observed spectra

$$N_{\text{ion}} = A_z \int \frac{dN_H}{d(\log \xi)} f_{\text{ion}}(\log \xi) \, d(\log \xi).$$

- $\xi$ and $f_{\text{ion}}$ are computed from photoionisation models
Equivalent H- column densities

Importance of different ions, Fe in particular

\[ N_H \sim \frac{N_{\text{ion}}}{f_{\text{ion}}(\xi_{\text{max}})A_{Z\odot}} \]
Absorption measure distribution (AMD): Observation

Discontinuity in the observed AMD

Observational evidence of Thermal instability (TI)? Holczer + 2007, Behar 2009
Absorption measure distribution (AMD): Observation

Mrk 509 (Detmers + 2011)

two AMD dips!
Absorption measure distribution (AMD): Modelling

- Broad band SED
- Gas density $n$
- Metallicity $Z$
- Column Density $N_H$
- Ionisation parameter, $\xi = L/nR^2$
- Solving the radiative transfer, ionisation equilibrium and thermal balance
- Main Codes: CLOUDY (Ferland +2013), TITAN (Dumont+ 2000), XSTAR (Kallman & Bautista 2001),..
Radiation Pressure Confinement (RPC) model (Stern+ 2014) using CLOUDY

RPC model in CLOUDY did not reproduce TI
AMD in Mrk 509: constant total pressure ($P_{\text{gas}}+P_{\text{rad}}$) single model

TITAN code reproduces TI problem with the normalisation!

Density dependence of AMD

for Mrk 509 SED, the position of AMD dip depends on density
RPC in Cloudy versus constant pressure in TITAN

TITAN (Constant total pressure)

- more accurate Accelerated Lambda Iteration (ALI) method
- radiation pressure is computed from radiation field and goes into the gas structure directly

\[ \mu \frac{dl_{\nu}}{d\tau_{\nu}} = l_{\nu} - \frac{j_{\nu}}{\kappa_{\nu} + \sigma_{\nu}} = l_{\nu} - S_{\nu} \]

CLOUDY (RPC)

- Escape probability method of radiative transfer

\[ dP_{gas}(\tau) = P_{rad} e^{-\tau} d\tau \]

- pressure induced by the trapped emitted radiation is not considered

Escape probability method versus ALI method (Dumont+ 2003)
Systematic study of AMD using TITAN

Adhikari+ 2017, in preparation
Systematic study of AMD using TITAN

Adhikari+2017, in preparation
Systematic study of AMD using TITAN: normalisation and position of dip in AMD

\[ N_H \geq 10^{23} \text{ cm}^{-2} \]

SED - with strong X-ray illumination

\[ N_H \approx 10^{21}-10^{22} \text{ cm}^{-2} \]

SED - with strong opt/UV component

Adhikari+ 2017, in preparation

normalisation is higher for SED with strong X-ray illumination
In case of SED with strong optical/UV component and for high density, free free heating dominates over the Compton heating.
TITAN model: SED with strong optical/UV component, $\log N_H = 22.48$, $\log n_H = 12$

data: Behar 2009
Summary

- Constant total pressure single component WA model explains the observed AMD in Mrk 509.

- Computations of AMDs with the constant pressure assumption for different SED components shows that the normalisation is higher for SED with strong X-ray illumination and weak optical/UV component.

- For the given SED, the position of AMD dip depends on the density of the absorber.
Back up slides...

Różańska +08, **Processes**

**Net bound–free (Ion. – Rec.)**
**Net free–free (H – C)**
**Net Compton (H – C)**
**Net bound–bound (H – C) LINES**

Solid line – $n = 10^{10}$ cm$^{-3}$
Dotted line – $n = 10^8$ cm$^{-3}$
Dashed line – $n = 10^6$ cm$^{-3}$