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Kinematics from spectral lines for AGN outflows based on time-independent radiation-driven wind theory

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Motivation

We build a bulk velocity-dependent photoionization model of the warm absorber of the Seyfert 1 galaxy NGC 3783. By adopting functional forms of the velocity of the flow and its particle density with radius, appropiate for radiation driven winds, we compute the ionization, temperature, line Doppler shift, and line optical depth as a function of distance.

Observations & Theory

Let us consider a radiation source with L~10^{44}-10^{47} ergs/s, arising from a supermassive (~10^8 Msun) black hole (BH). Material ~ 0.1-1 pc from the BH only needs to absorb a small fraction of this energy to be accelerated to few thousand km/s in Seyfert galaxies and up to 0.1-0.2c in high redshift Quasars Arav (1994),Ramirez (2008),Saez (2009),Chartas (2009). By conservation of mass the number density of hydrogen can be written in spherical symmetry as

$$n_H(r) = \frac{\dot{M}}{\left(4\pi r^2 v(r) u m_H\right)}$$

We adopted a velocity law v(r) compatible with the predictions of the radiatively driven wind theory Castor(1975).

$$w(x) = w_0 + (1 - w_0)\left(1 - \frac{1}{x}\right)^{\beta}$$

Results

We have computed photoionized wind-flow models for the X-rays spectrum of NGC 3783. We studied singly continously absorbing models as well as multiple optically thin components linked through an analytic wind velocity law. It is found that the singly continuously absorbing model yields gas column densities and optical depths too high, unless one adopts very low (~$10^{(3-4)}$ cm^{-3}) densities and metal abundances (~0.01 solar). On the other hand, the multicomponent model is able to reproduce observations vary well. For this model we compute ionization properties of the material using a velocity law compatible with a radiative wind.

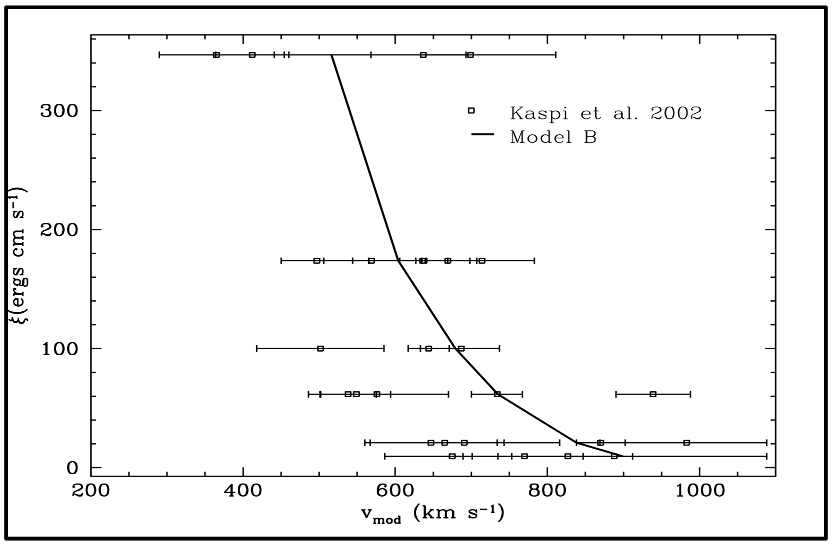

Fig.1: Relationship between the ionization parameter and velocity. The solid line is the theoretical prediction for model B. The open squares with error bars are points with velocities taken from Kaspi(2002).

Our model is consistent with $\log(n_0)$=11.35 [cm^{-3}], a launching radii of log(r0)=15 [cm], and a terminal velocities of v_{term} ~1500 km/s, which yields a mass loss rate of the order of M_{out} ~ 1 M_{sun}/yr (assuming a volumic factor fvol=0.1). If we assume an ionizing luminosity of L~2 x 10^{44} ergs/s Peterson(2004), and accretion efficiency of e=0.1, the Eddington mass accretion mass is M_{Edd} ~ 0.01 M_{sun}/yr. This is consistent with the result of Crenshaw(2007) for NGC 4151, and Ramirez(2008) for APM, of M_{out}/M_{Edd} > 10. However, it is different from the supposition made by Goncalves(2006), of M_{out}/M_{Edd} <1, using their photoionization code TITAN, for computing the single medium in pressure equilibrium.

References:

- *Arav et al. 1994, ApJ, 432, 62.*
- *Goncalves 2006, Apj, 451, L23.*
- *Ramirez 2008, A&A, 489, 57.*
- *Saez et al. 2009, ApJ, 697, 194.*
- *Chartas et al. 2009 Apj, 706, 644.*