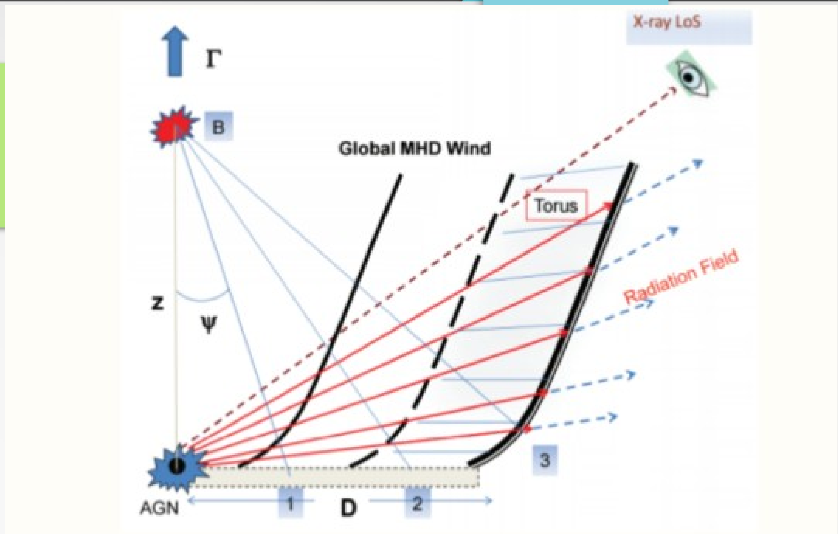
Is the Blazar Sequence related to accretion disk winds?

Stella Boula[1*], Apostolos Mastichiadis[1], Demosthenes Kazanas[2]

[1]Department of Physics, University of Athens, Zografos Greece
[2]NASA Goodard Space Flight Center, Laboratory for High-Energy Astrophysics

[*]stboula@phys.uoa.gr

The Model



The kinetic equation for electrons is described by

$$\frac{\partial n_e(\gamma,t)}{\partial t} + \frac{n_e(\gamma,t)}{t_{esc}} = Q_{e,inj} + L_e$$

where n_e is the differential electron density and Q_e, L_e are the injection and energy loss operations for electrons respectively. These are defined as

$$Q_{e,inj} = \begin{cases} k_{e_1}\gamma^{-p} & \text{for } \gamma_{min} \le \gamma \le \gamma_{br} \\ k_{e_2}\gamma^{-q}e^{-\gamma/\gamma_{max}} & \text{for } \gamma_{br} \le \gamma \le \gamma_{max}, \end{cases}$$

$$\gamma_{max} = \frac{3m_ec^2}{4\sigma_T c t_{acc} U_{tot}},$$

$$L_e = \frac{4}{3}\frac{\sigma_T}{m_ec^2}\frac{\partial}{\partial\gamma}[\gamma^2 n_e(\gamma,t)U_{tot}],$$

where $\gamma_{br} = 0.1\gamma_{max}$ and U_{tot} the total energy density. This is given by

$$U_{tot} = U_B + U_{ext} + U_{ssc}$$

The acceleration time t_{acc} is defined from the first order Fermi acceleration as

$$t_{acc} = \tau_{FI} \ge \frac{6\gamma m_e c^3}{eBu_s^2}$$

where u_s the velocity of the shock.

The wind's particle density is

$$n = n_0\frac{r_0}{r}$$

where $r_0 = r_s$, $n_0 = \frac{\eta_w \dot{m}}{2\sigma_T r_s}$, $\dot{m} = \frac{\dot{M}}{M_{Edd}}$ the mass rate normalized to Eddington mass rate, r_s is Schwartzchild radius, η_w the ratio of the mass-outflow rate in the wind to the mass-accretion rate $\dot{m}$, asumed here to be $\eta_w \simeq 1$ and σ_T the Thomson cross section. Photons from the accretion disk could be scattered on wind particles. We assume a sperical region between radii R_1 and R_2, therefore the optical depth in first order is

$$\tau_T = \int_{R_1}^{R_2} n(r)\sigma_T dr = n_0\sigma_T \ln\frac{R_2}{R_1}$$

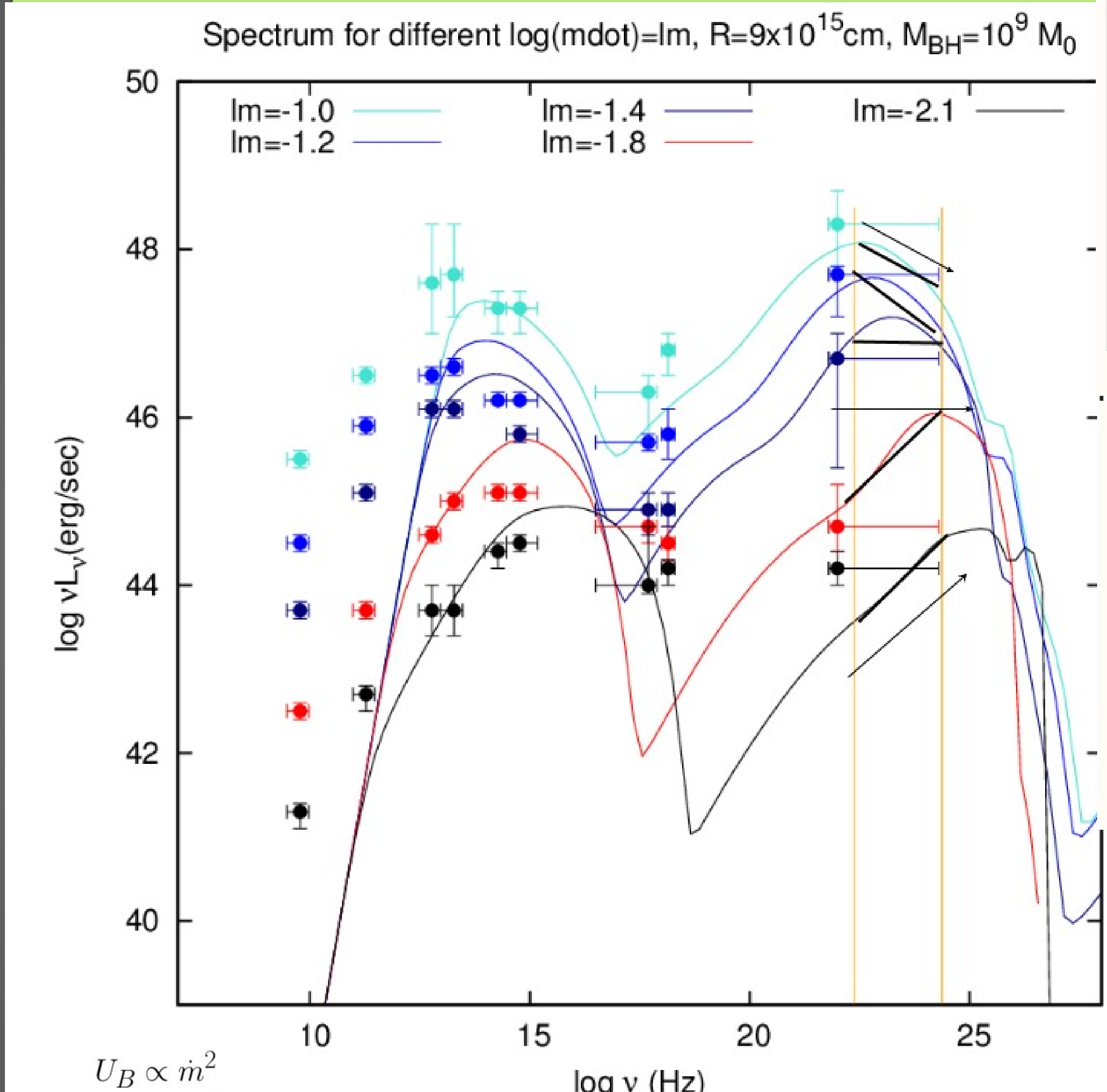
In the case of $\tau_T <<$ the photon energy density of the scattered accretion disk photons up to distance R_2 is

$$U_{ext} = \frac{\eta_{ext}L_{acc}\tau_T}{4\pi R_2^2 c},$$

where η_{ext} the radiation to accretion efficiency, $L = \epsilon\dot{m}^2 L_\odot \hat{M}$ the ionizing luminosity from the disk and $L_\odot = 1.3\times10^{38} M_\odot erg\ s^{-1}$ is the Eddington luminosity, ϵ is the effisiency of conversation os mass into radiation for $\dot{m} = 1$ and $\hat{M} = \frac{M}{M_\odot}$, where $M_\odot$ is one solar mass.

Fukumura et al, ApJ 715, 2010

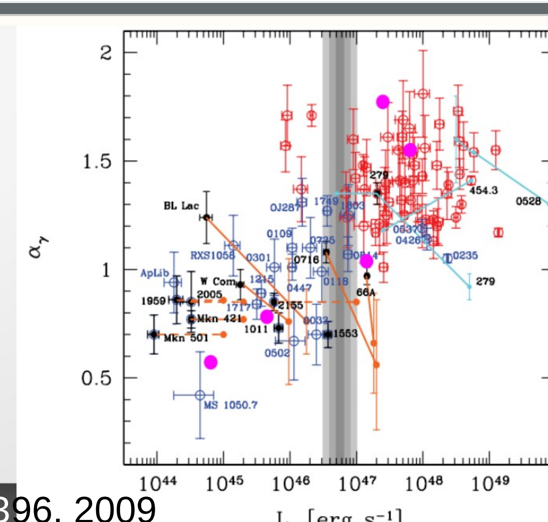
Mastichiadis & Kirk, A&A 295, 1995



$\log \dot{m}$	B (G)	$\log \gamma_{br}$	$\log l_{ext}$	$\log l_e$
-1.0	2.40	2.90	-2.0	-1.9
-1.2	1.51	3.01	-2.1	-2.3
-1.4	0.95	3.16	-2.5	-2.7
-1.8	0.38	3.50	-3.4	-3.5
-2.1	0.19	3.60	-4.5	-4.1

$1-\alpha_\gamma$	α_γ	Γ_γ	$\log(L_\gamma)$ (erg/sec)
-0.28	1.28	2.28	48.1
-0.30	1.30	2.30	47.7
-0.05	1.05	2.05	47.2
0.24	0.76	1.76	46.0
0.45	0.55	1.55	44.7

$$U_B \propto \dot{m}^2$$
$$U_{ext} \propto \dot{m}^3$$
$$\gamma_{max} \propto \dot{m}^{-2}(1+\dot{m})$$
$$L_e^{inj} \propto \dot{m}^2$$
$$t_{acc} \propto \dot{m}^0$$



Ghisellini et al, MNRAS 396, 2009