

Polarization in AGN Broad Emission Lines – The Central Source Anizotropy and Gas Kinematics

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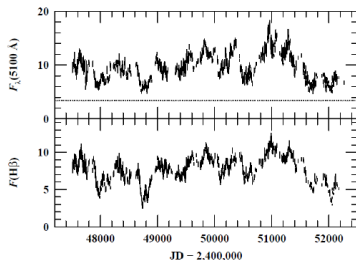
Astronomical observatory of Belgrade
L'Observatoire astronomique de Strasbourg

May 31, 2016



Physical characteristics

- Compact object. Volume of the emitting regions is $\ll 1\text{pc}^3$.
- High luminosity objects: $L \sim 10^{42} - 10^{48}$ erg/s.
- Amplified continuum from gamma and X-rays to radio emission.
- Broad and narrow emission lines.
- Variable radiation.
- Polarized radiation.
- Many different types.

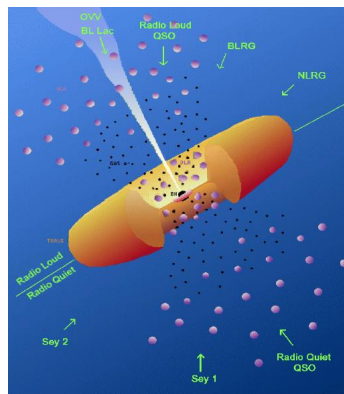


NGC5548 Peterson et al. (2002)

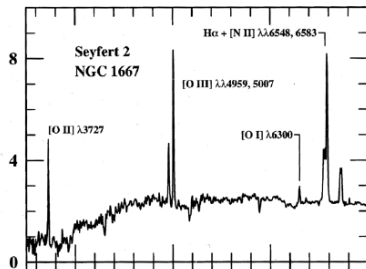
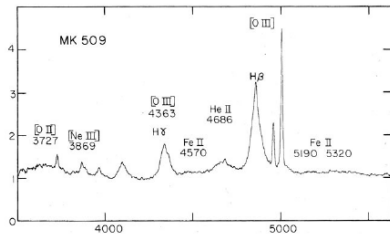


Unified model

- Supermassive black hole in the center.
- Broad and narrow line regions.
- Dusty torus.
- Jets.
- Different types, depending on the viewing angle.

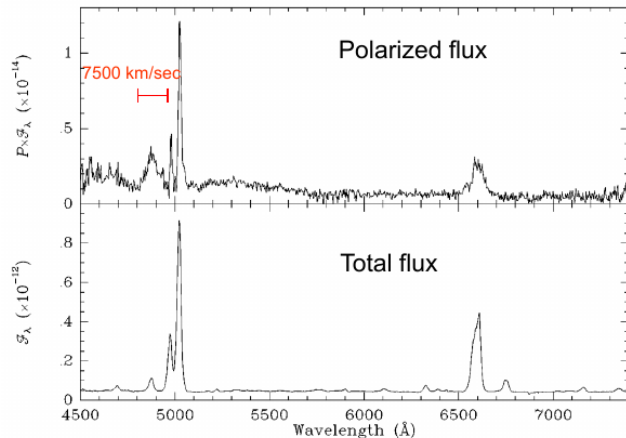


AGN spectra



Polarization observations

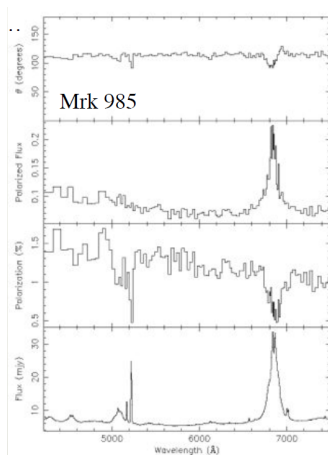
- Broad lines in polarized spectra of NGC1068 (Antonucci & Miller 1985).



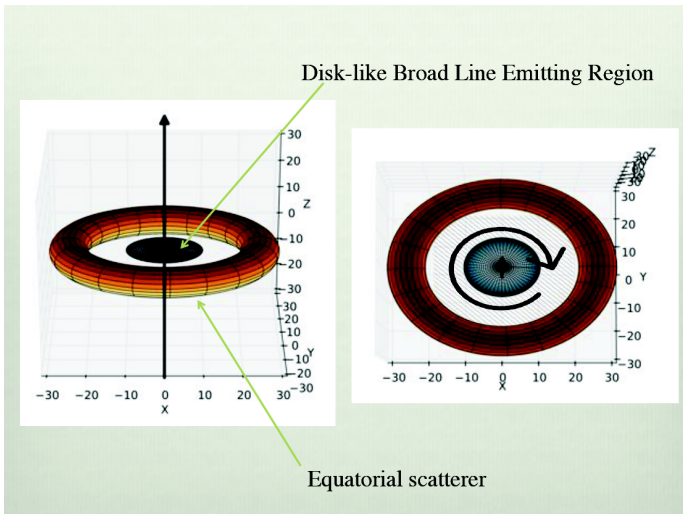
Polarization observations

- Characteristic polarization angle as signature for equatorial scattering in Sy 1s.

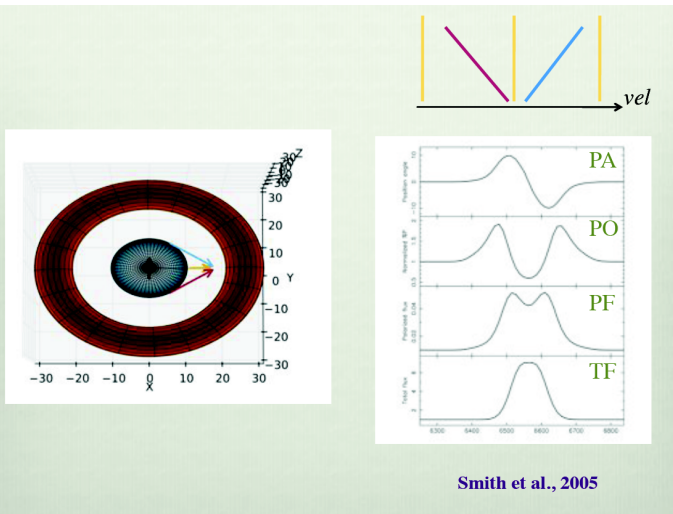
Smith et al. 2002



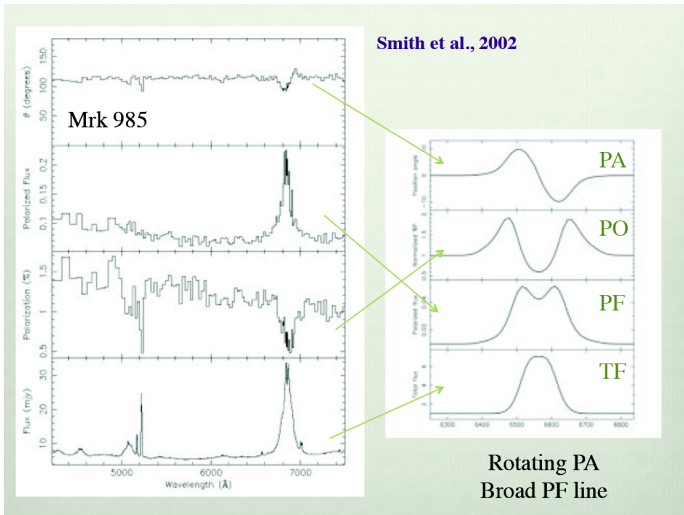
Equatorial scattering



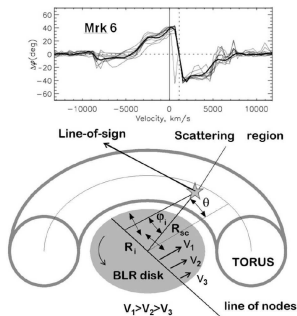
Equatorial scattering



Equatorial scattering



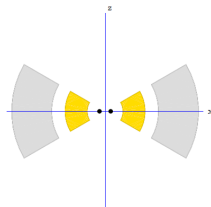
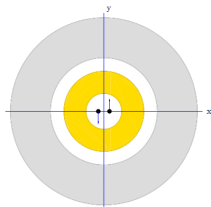
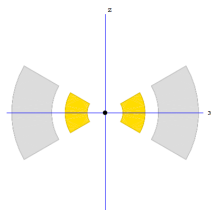
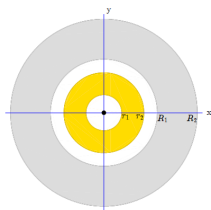
- Test the similar model in the case of binary black hole scenario.
- Measuring SMBH masses using polarization (Afanasiev & Popovic 2015).



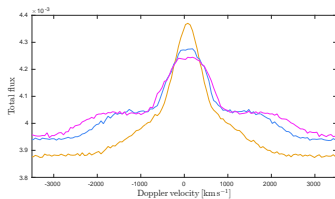
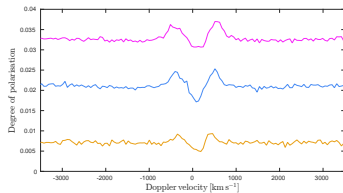
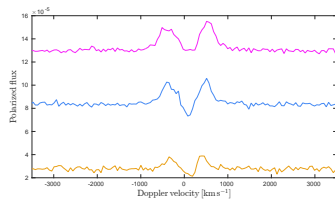
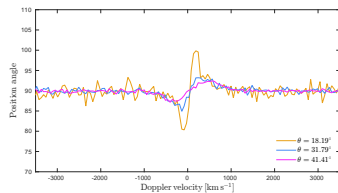
- Central engine consists of continuum radiation, emitted by
 - 1 Supermassive black hole (SMBH) $\mathcal{M}_{\text{BH}} = 1 \times 10^8 \mathcal{M}_{\odot}$;
 - 2 Two SMBHs orbiting around each other at the distance of 20 light days with equal masses $\mathcal{M}_{\text{BH}} = 5 \times 10^7 \mathcal{M}_{\odot}$.
- BLR and scattering region are modeled with flared disk geometry with Keplerian motion and an opening angle of 30° .
- We used 3D Monte Carlo radiative transfer code *STOKES* (Marin et al. 2012, Goosmann et al. 2013)



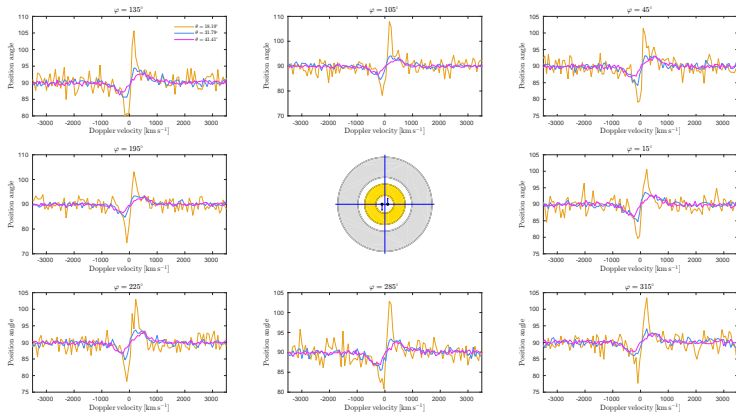
Polarization modeling using *STOKES*



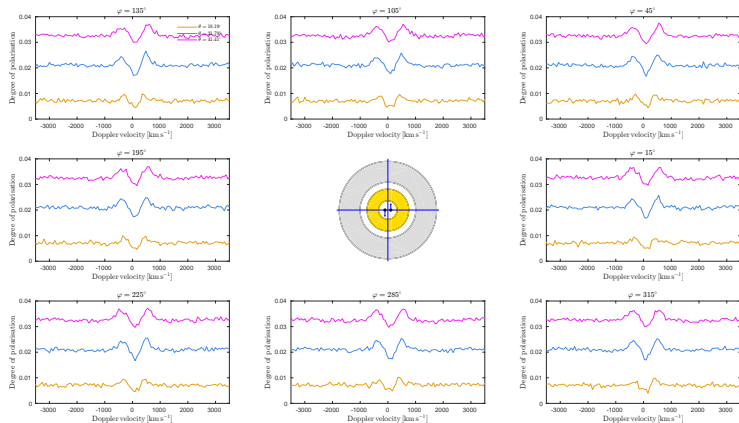
Results: single black hole scenario



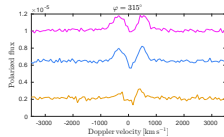
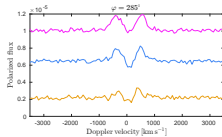
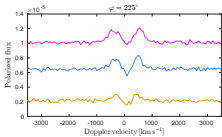
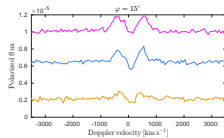
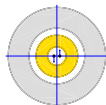
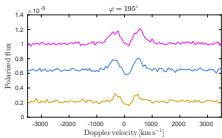
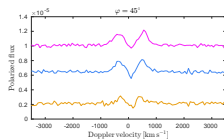
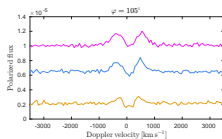
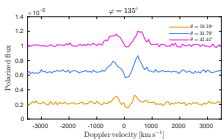
Results: Polarization angle



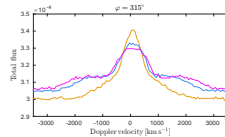
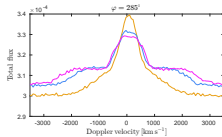
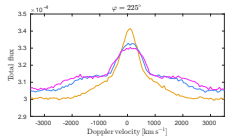
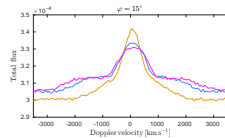
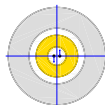
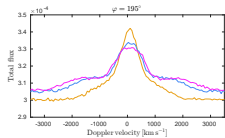
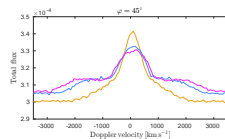
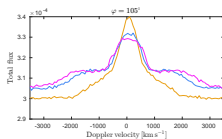
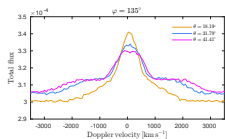
Results: Degree of polarization



Results: Polarized flux

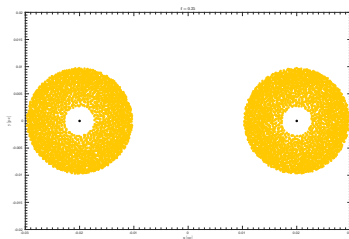


Results: Total flux



Conclusions and future work

- If SMBH binaries are embedded into a single BLR, we observe them as one.
- Test the model with two BLRs (in progress).



Thank you

