Discovery and improvement of a radiative transfer code for the study of AGN

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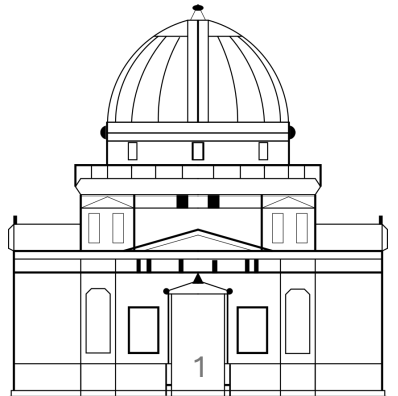
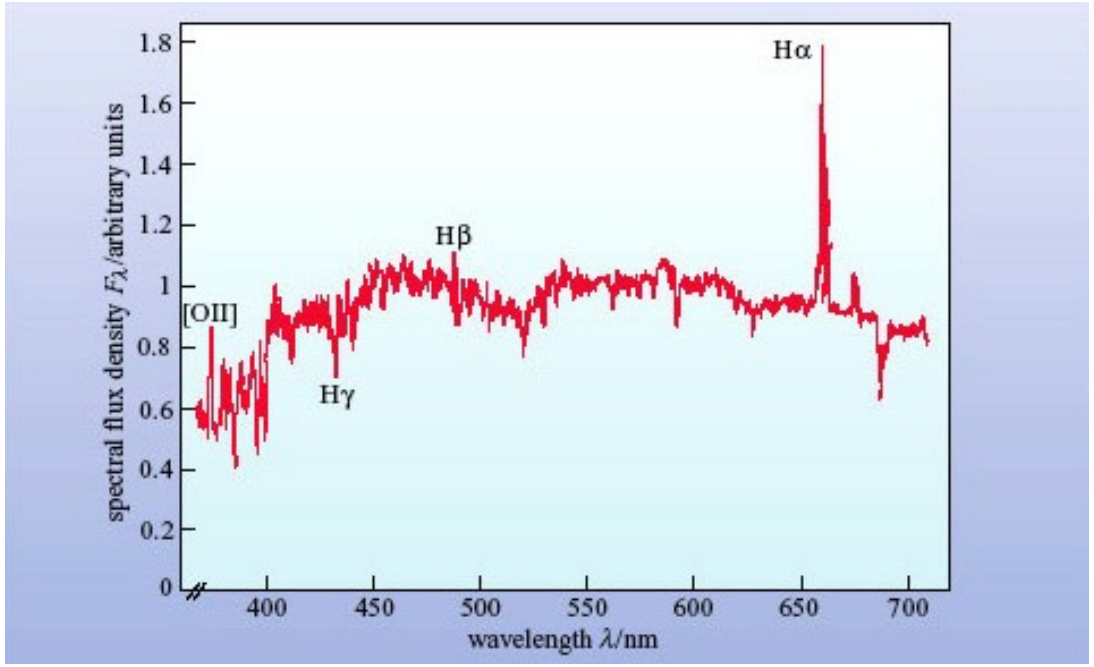


A point-like source

Normal galaxy (NGC 4750)

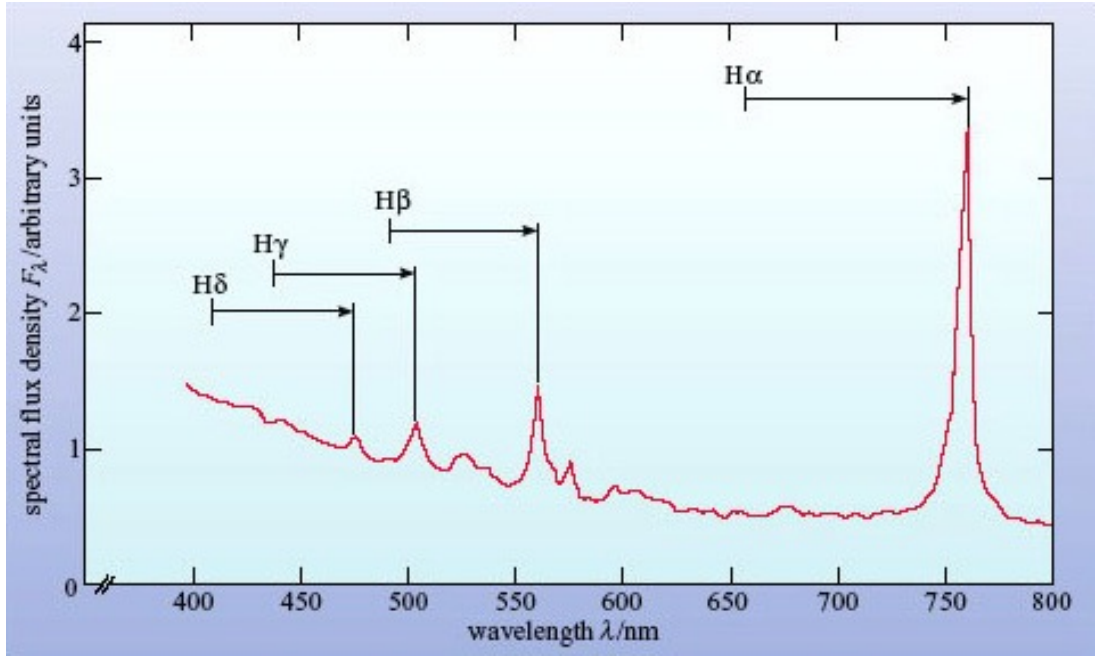
- Absorption & emission lines (HII regions)



R.C. Kennicutt, Astrophysical Journal, Vol 388, p. 310, © 1992 The American Astronomical Society

3C273 source

- Strong Balmer emission lines (H α , H β , H γ ...)
- Redshifted source (z = 0.158)
- Very powerful flux L > 10^{12} L_{sun}
- Strong radio emission
- Stochastic luminosity variation

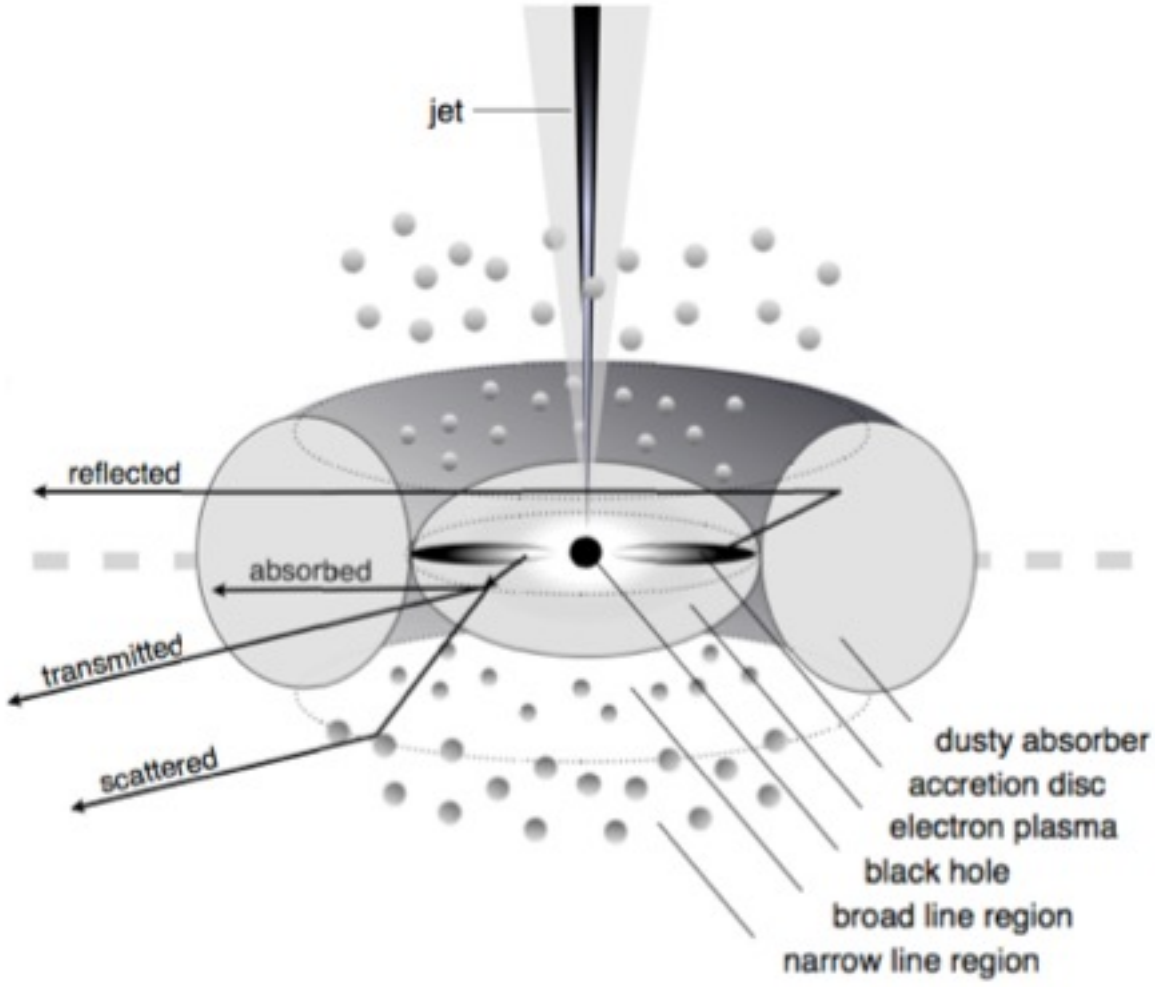


Kaufmann III, W.J., Galaxies and Quasars, 1979. W.H. Freeman and Company Publishers

AGN = Active Galactic Nuclei

What is the power source of this phenomenon?

ACCRETION DISK



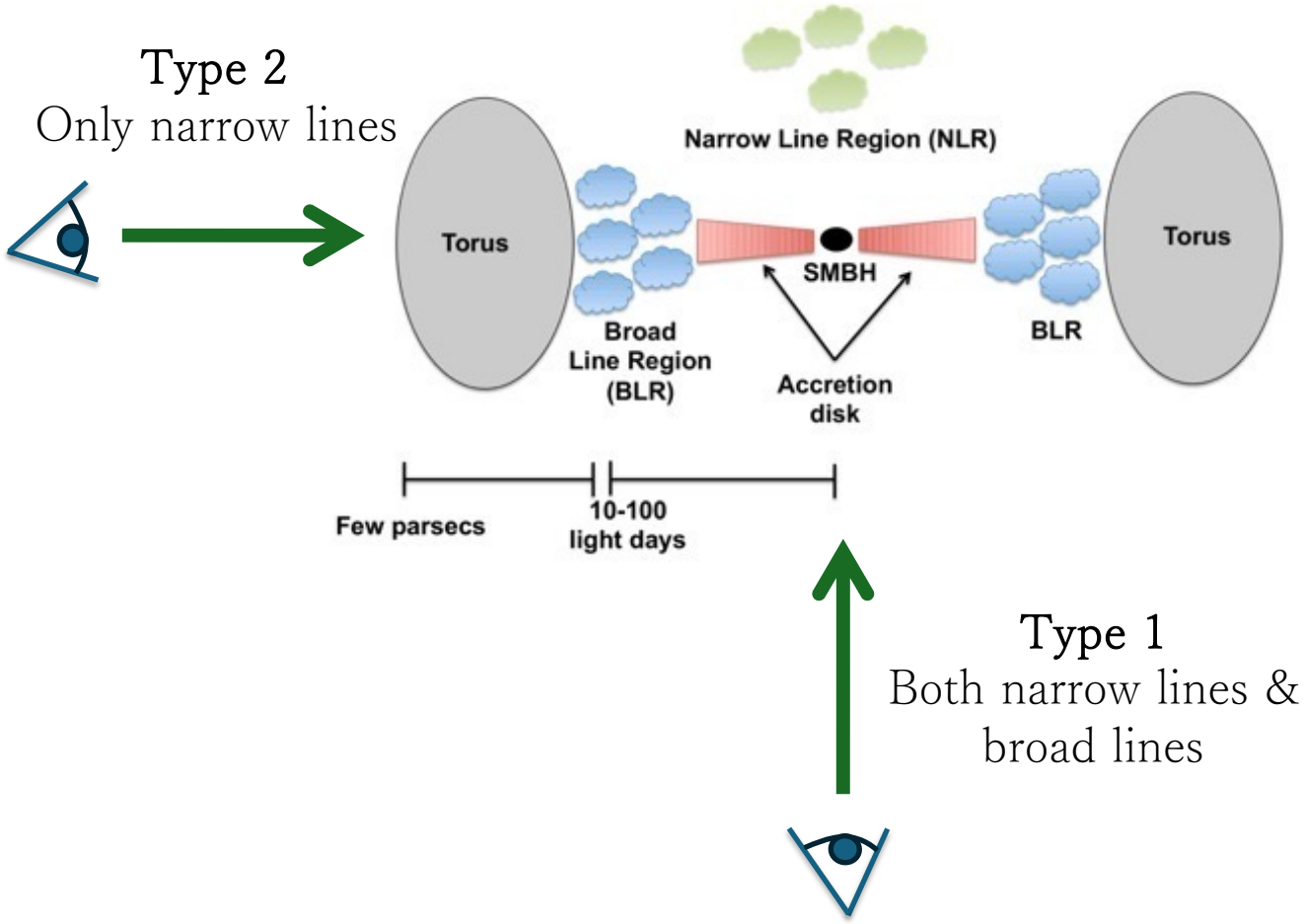
Adapted from Beckmann & Shrader (2012), Sketch of the basic ideas of the unified AGN model.

What's in an AGN?

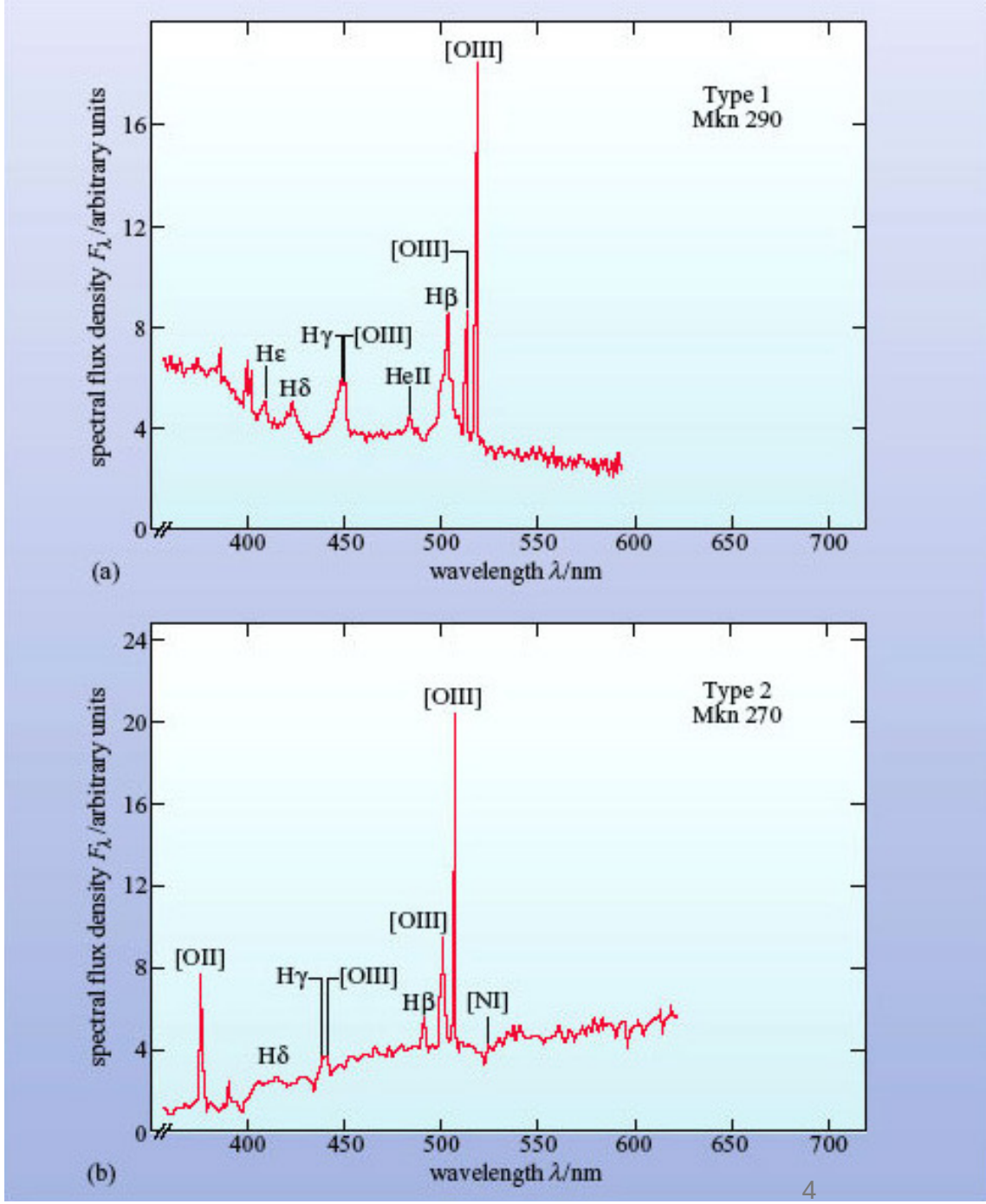
- Nucleus
- BLR (=Broad Line Region)
- NLR (=Narrow Line Region)
- Torus
- Jets (or not)
- Lobes (or not)

Type 1/Type 2 AGN

Type 2
Only narrow lines



Type 1
Both narrow lines &
broad lines



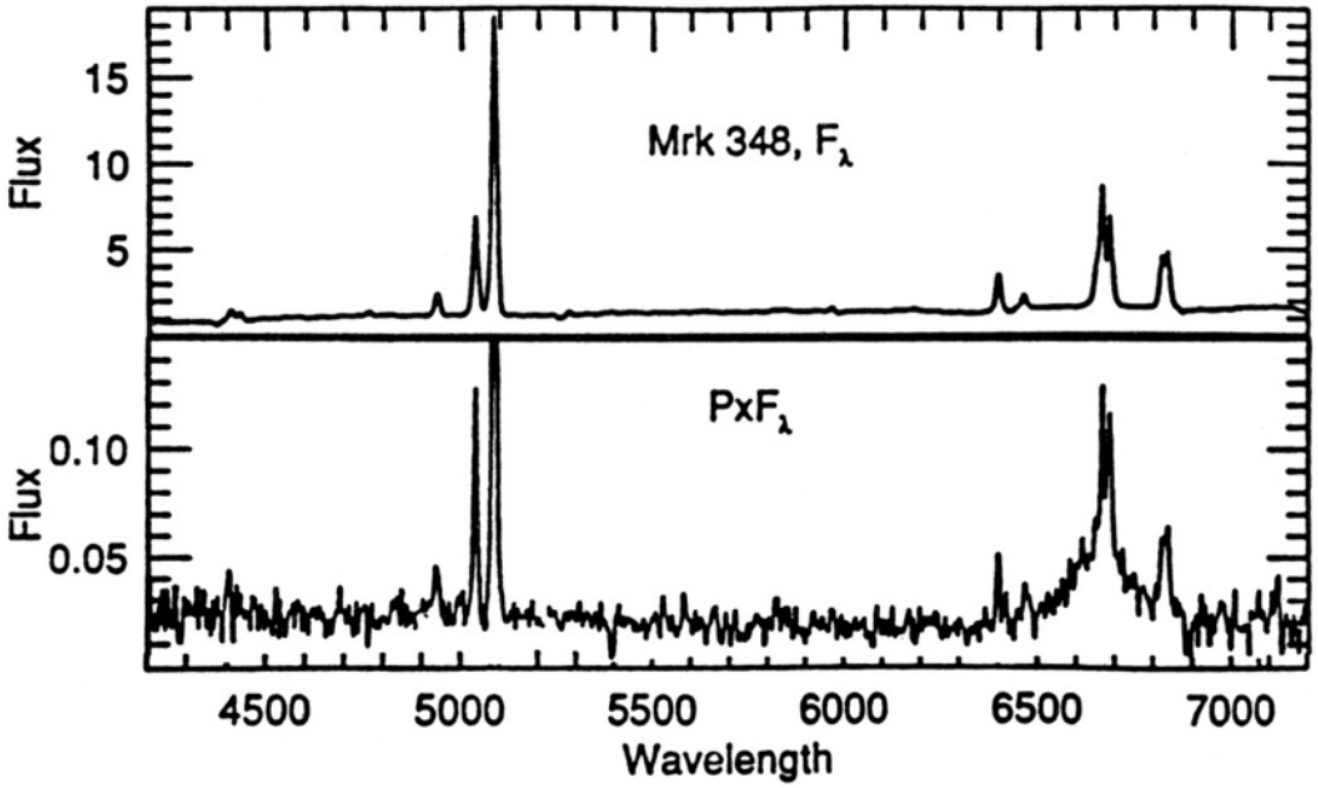
Netzer, H. (1990) AGN emission lines, in Blandford, R.D., Netzer, H. and Woltjer, L.

Spectro-polarimetry

Spectroscopy
analysis of object luminosity/flux as a function of wavelength

+

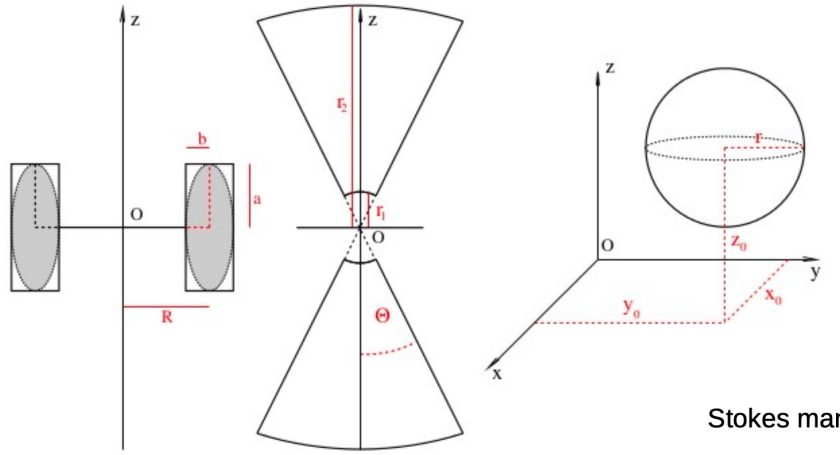
Polarimetry
Measurement of light polarization



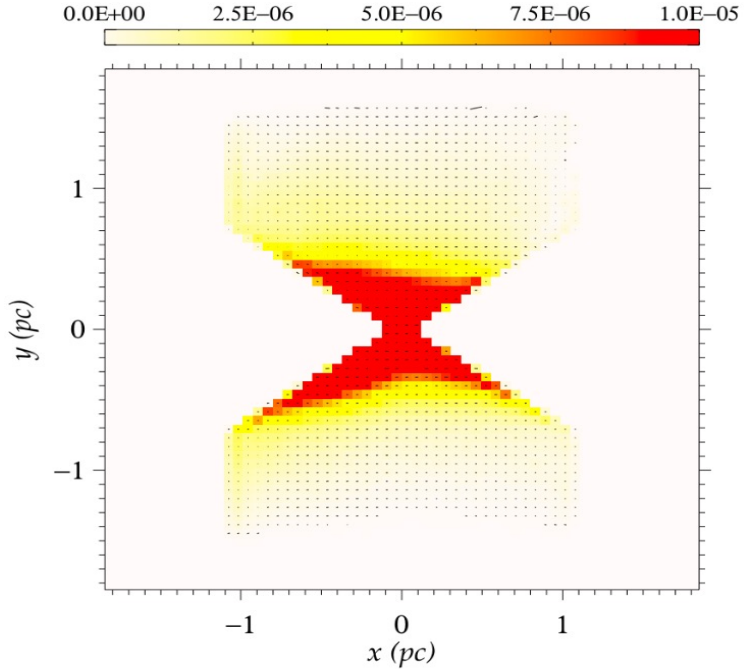
Marin, F. (2019). The Panchromatic Polarisation Signatures of Active Galactic Nuclei.

Radiative transfer code STOKES

- Monte Carlo code for photons emission and interaction
- Modelisation : Various geometries
- Optical, UV polarization (and now IR)



Stokes manual



http://www.stokes-program.info/

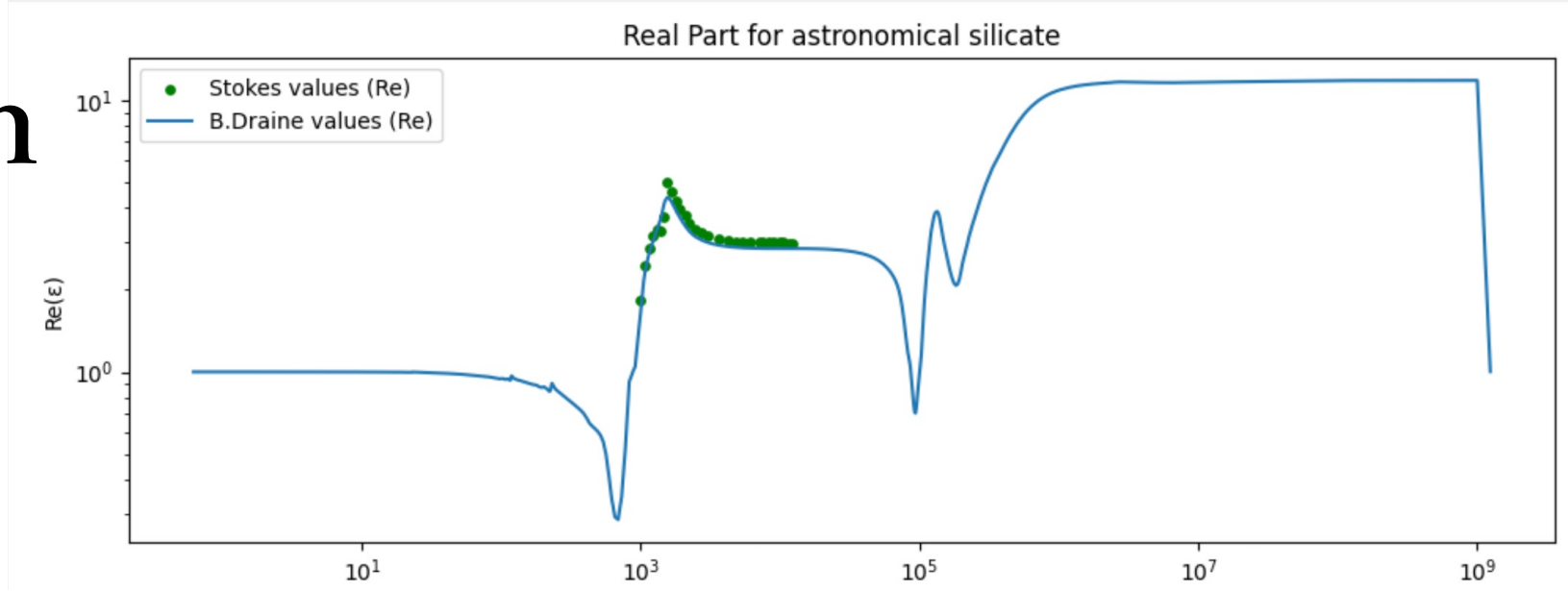
IR contribution

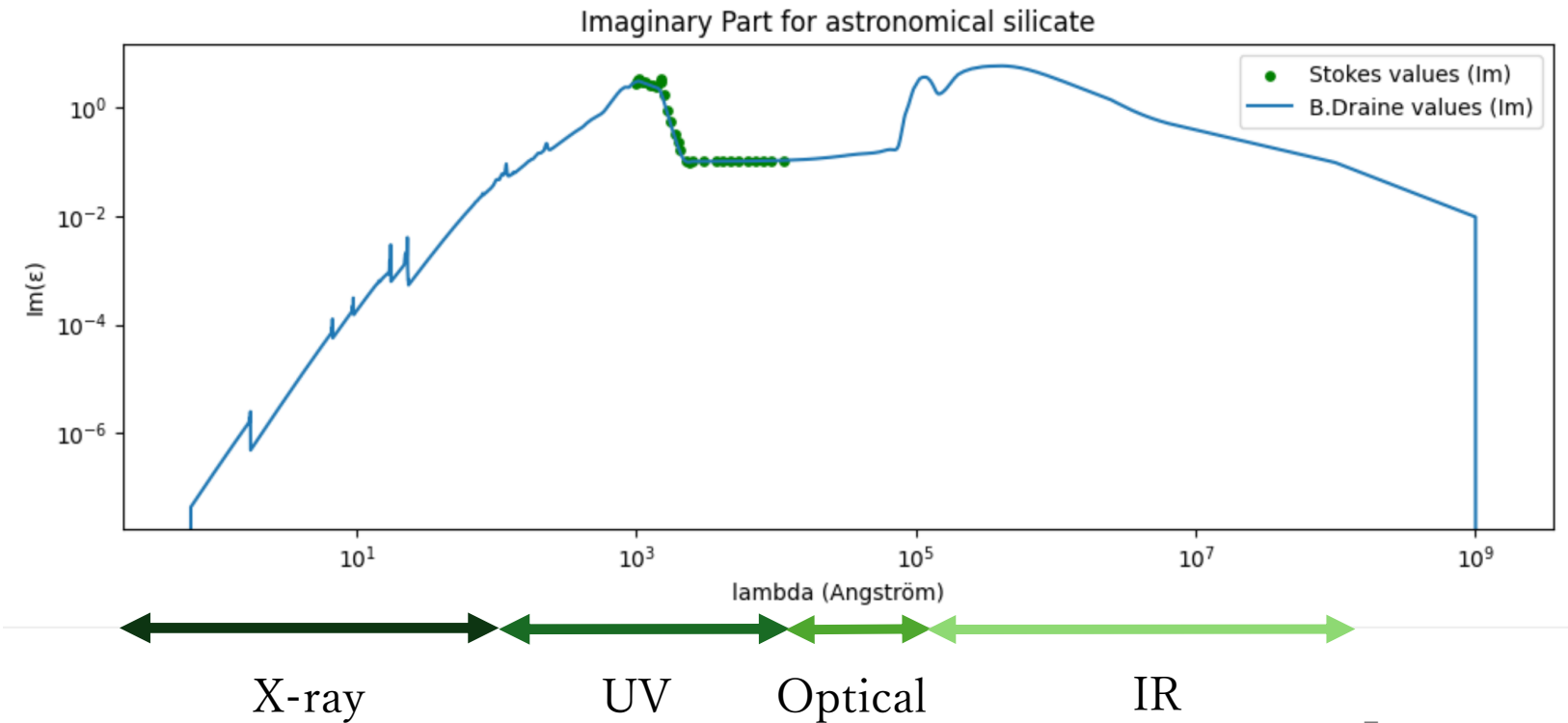
Dielectric function :

$$\varepsilon(\omega) = \mathrm{Re}(\varepsilon) + i\,\mathrm{Im}(\varepsilon)$$

Absorption — Re-emission

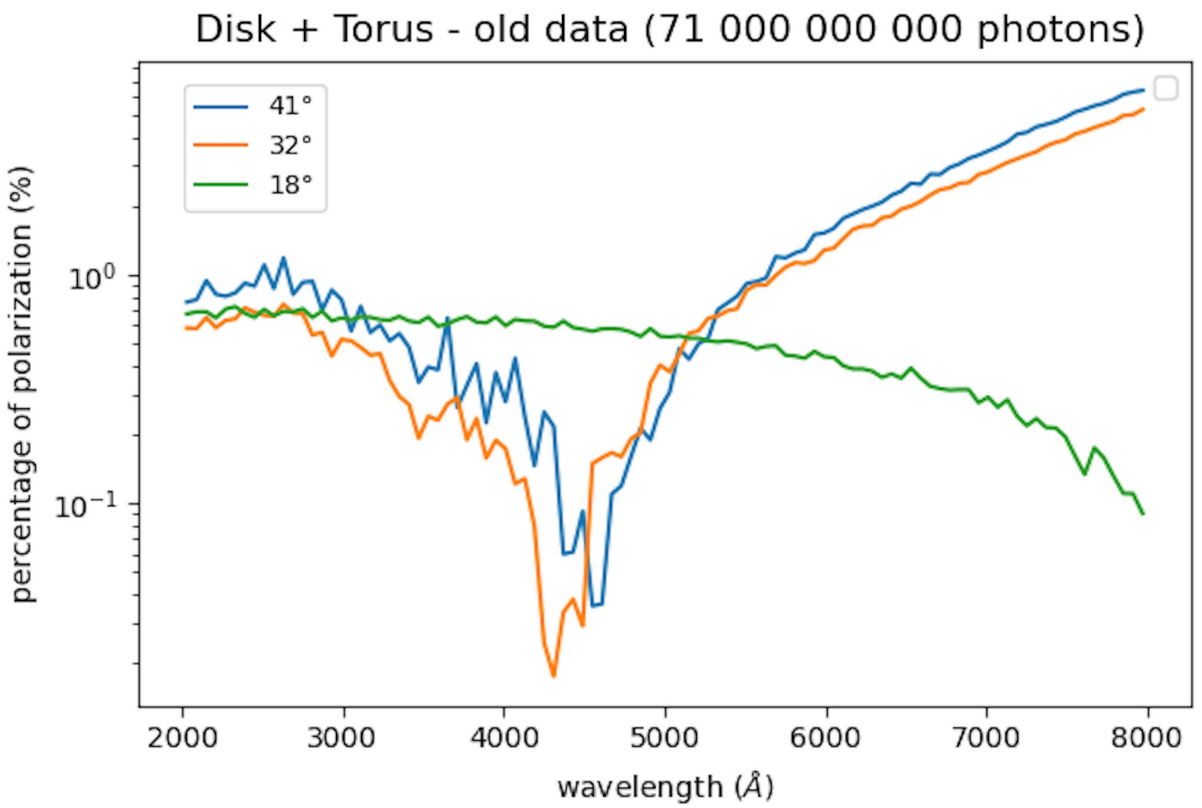
→ Necessary to understand how AGN dust interacts with the electromagnetic radiation emitted



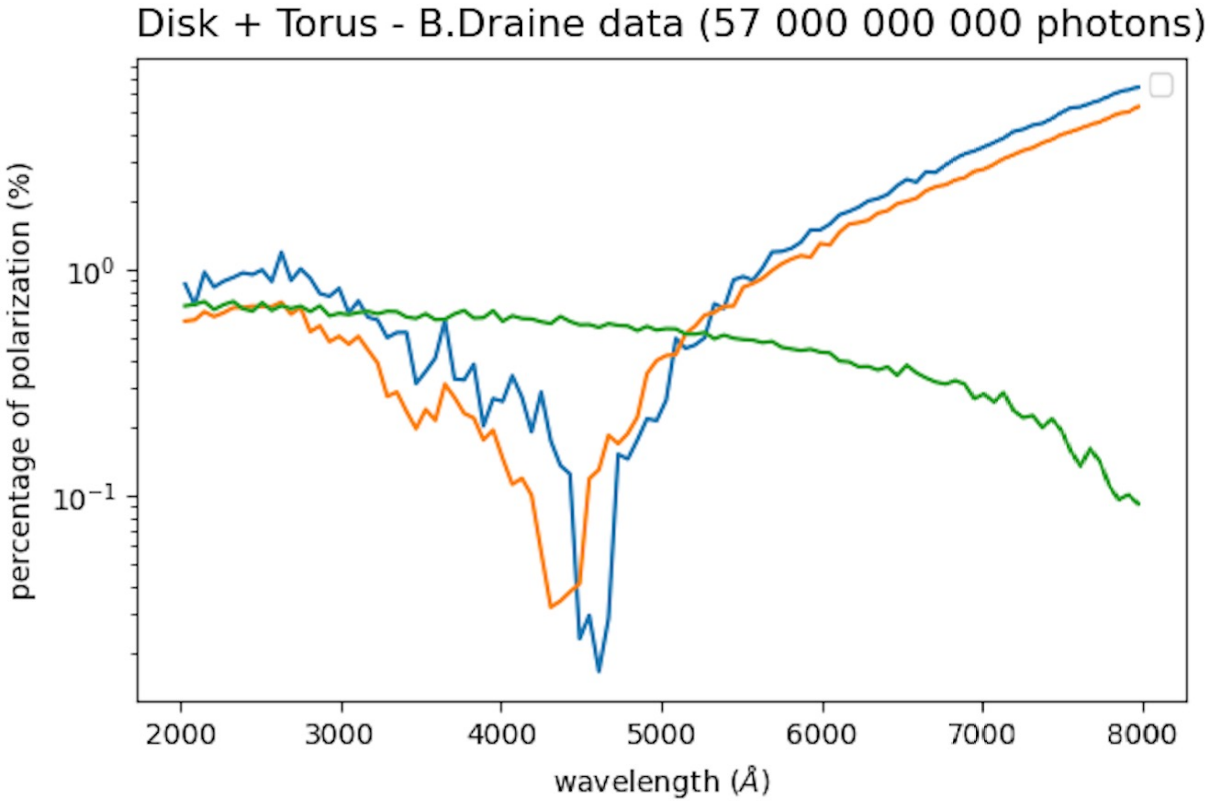


X-ray — UV — Optical — IR

Old data

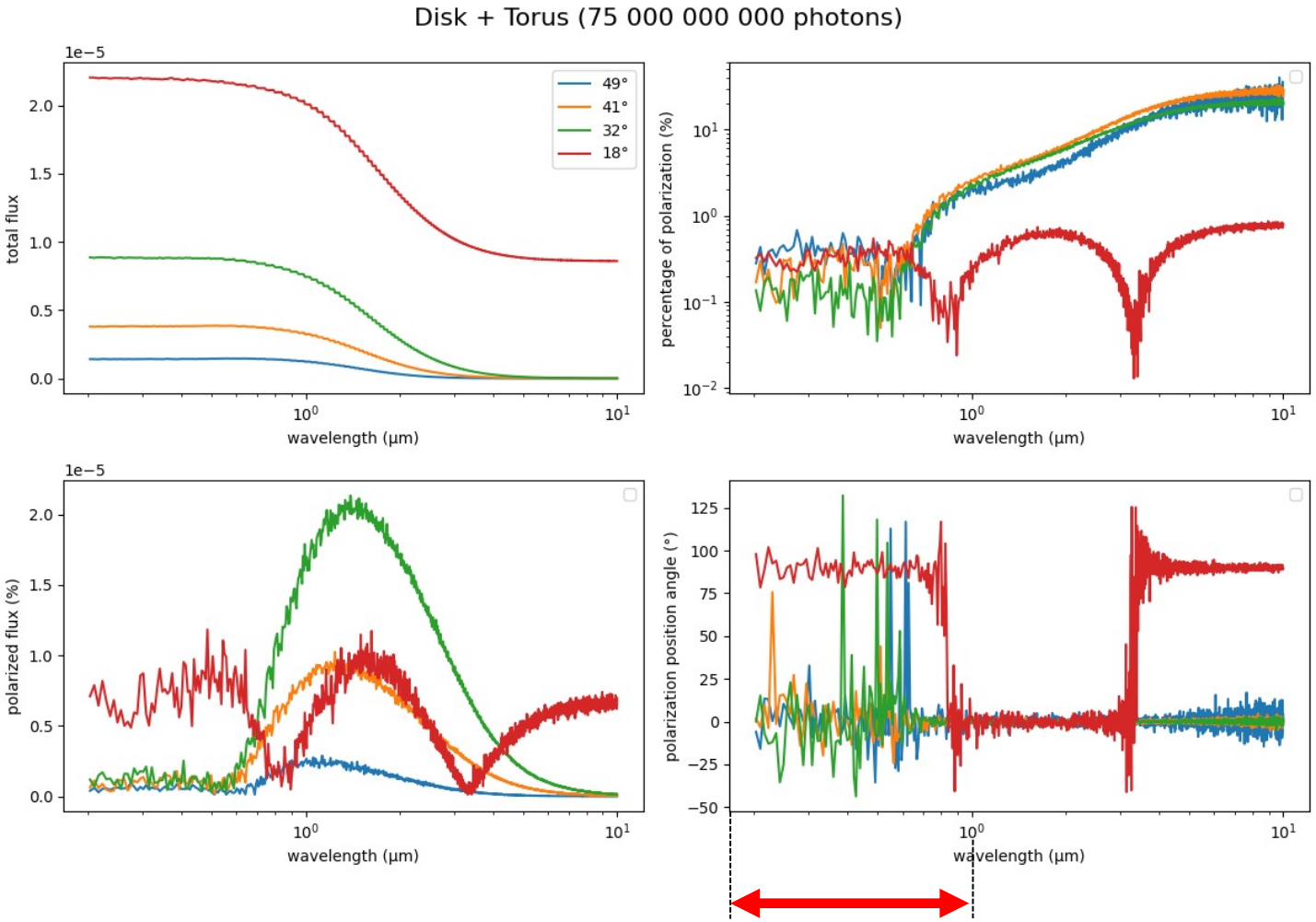


New data (B. Draine dielectric functions)



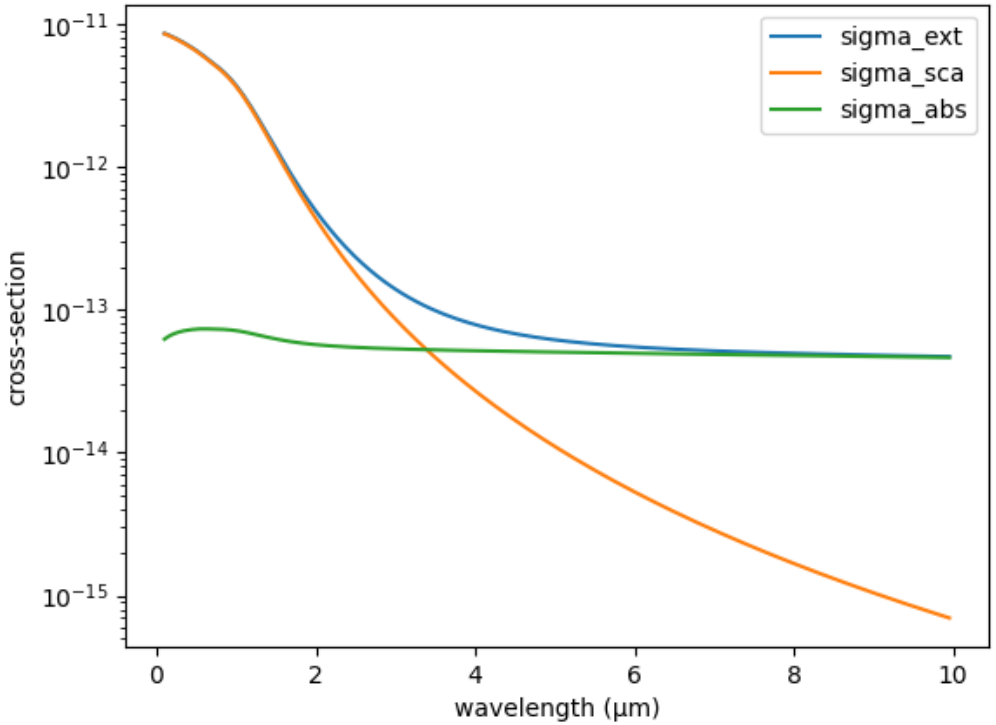
→ Much higher wavelength precision (more bins) + extension from X-rays to radio

Infrared spectrum



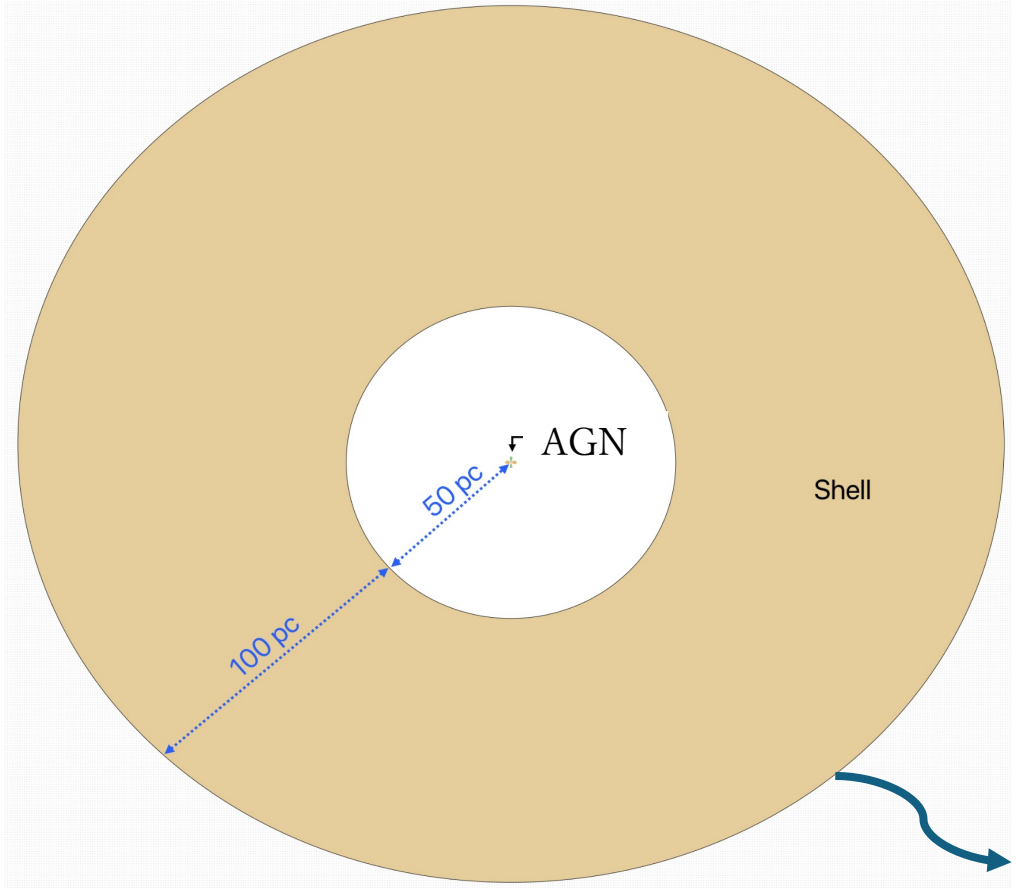
STOKES stopped here !

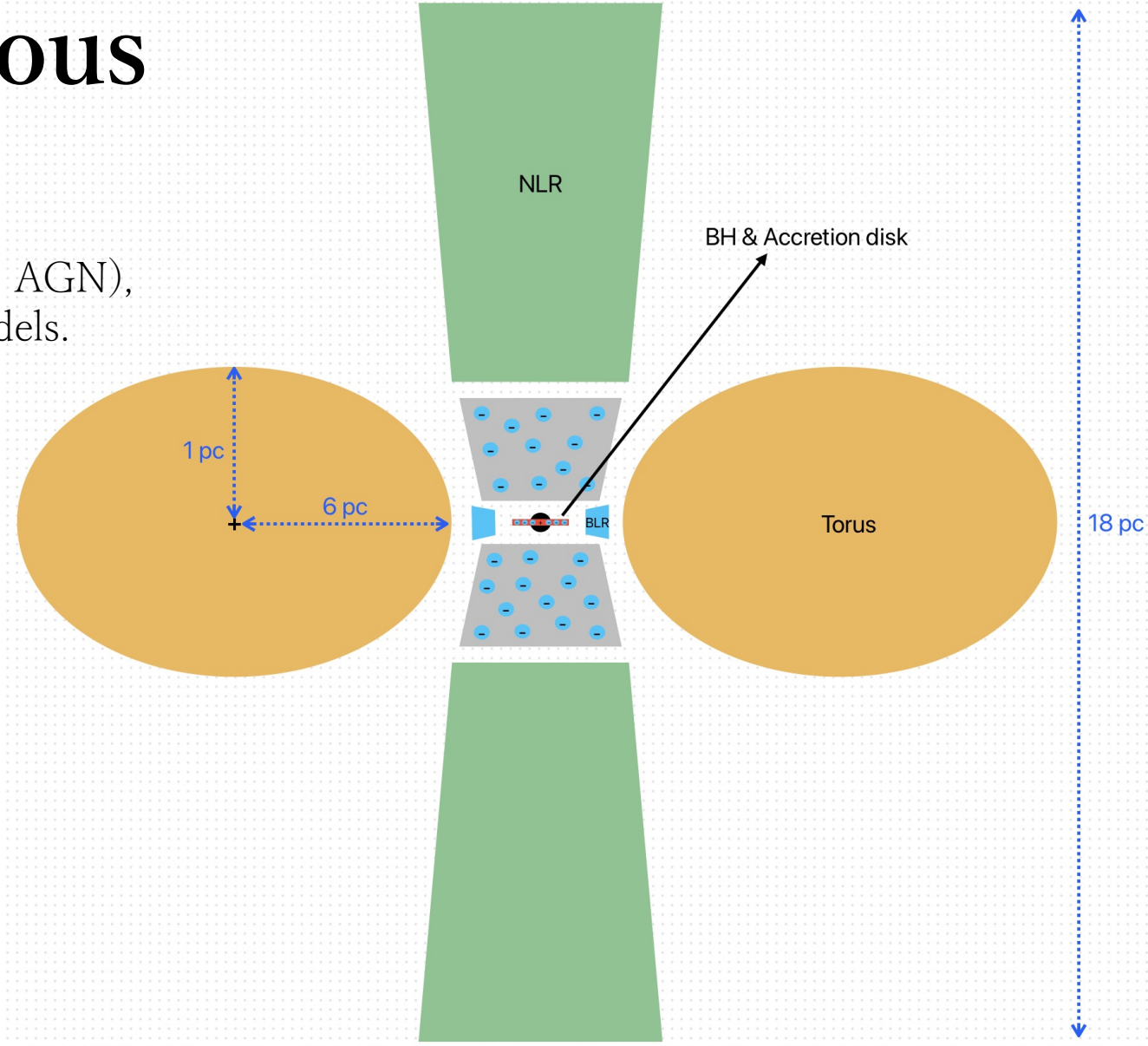
Cross-sections



ULIRG (Ultra-Luminous Infrared Galaxy)

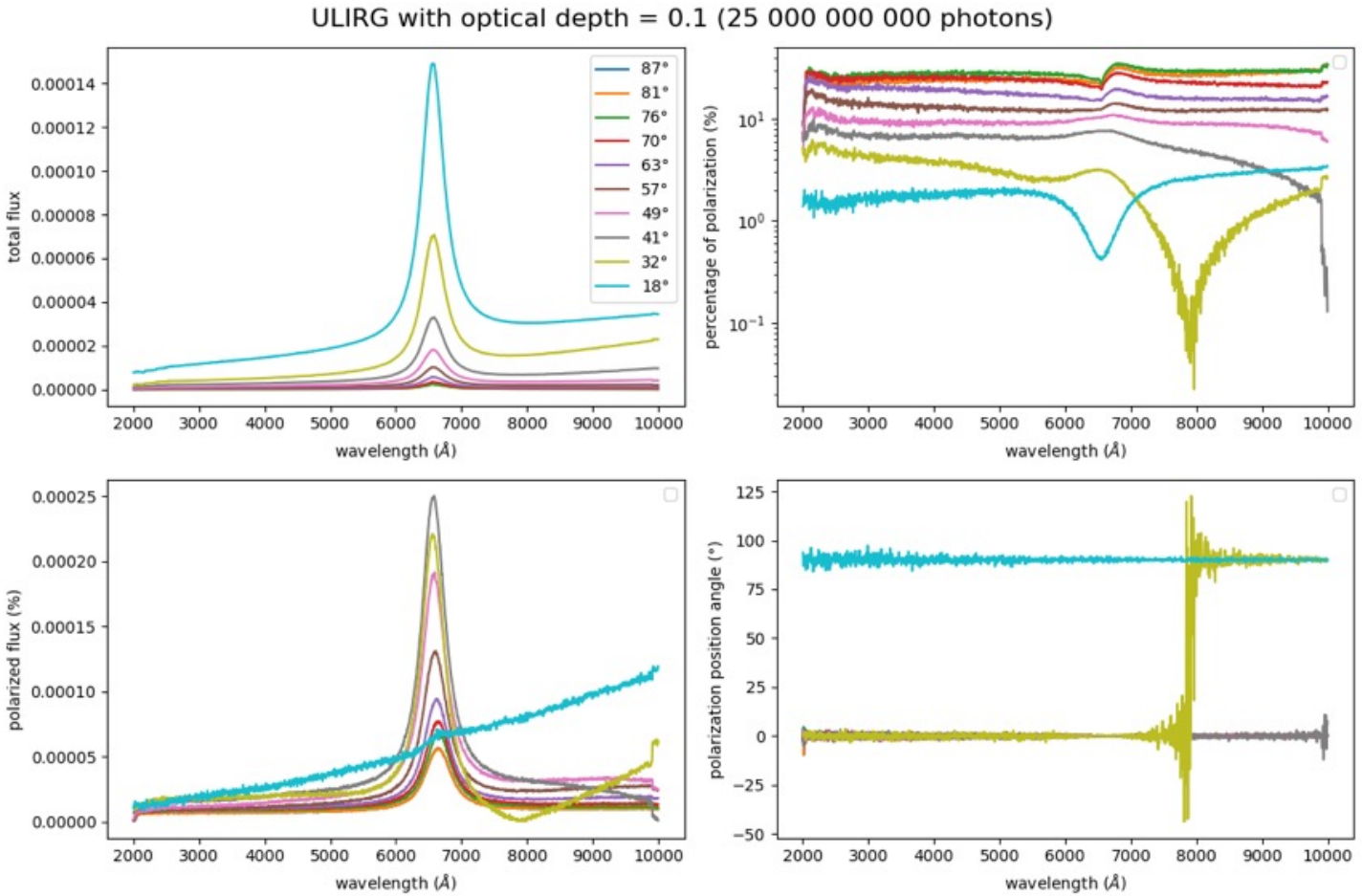
The most dust-dominated objects (which may contain AGN), making them ideal targets for testing improved dust models.

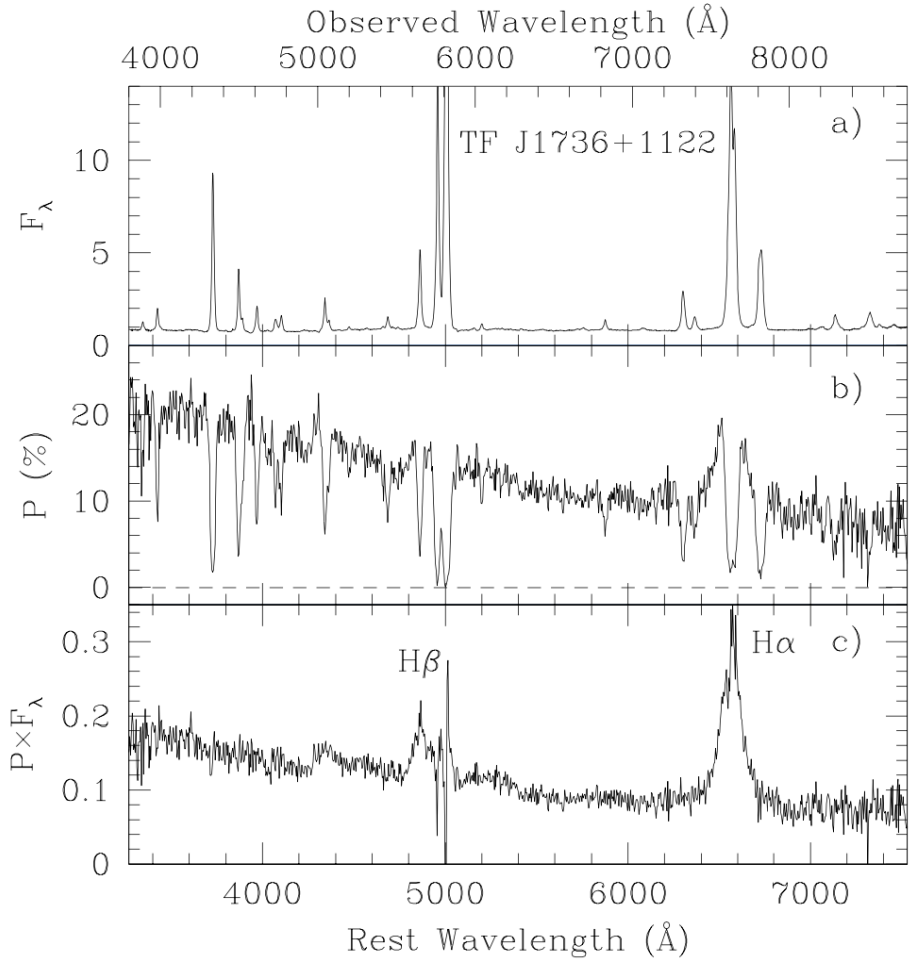




Optically thick dust shell

Simulation VS Observation

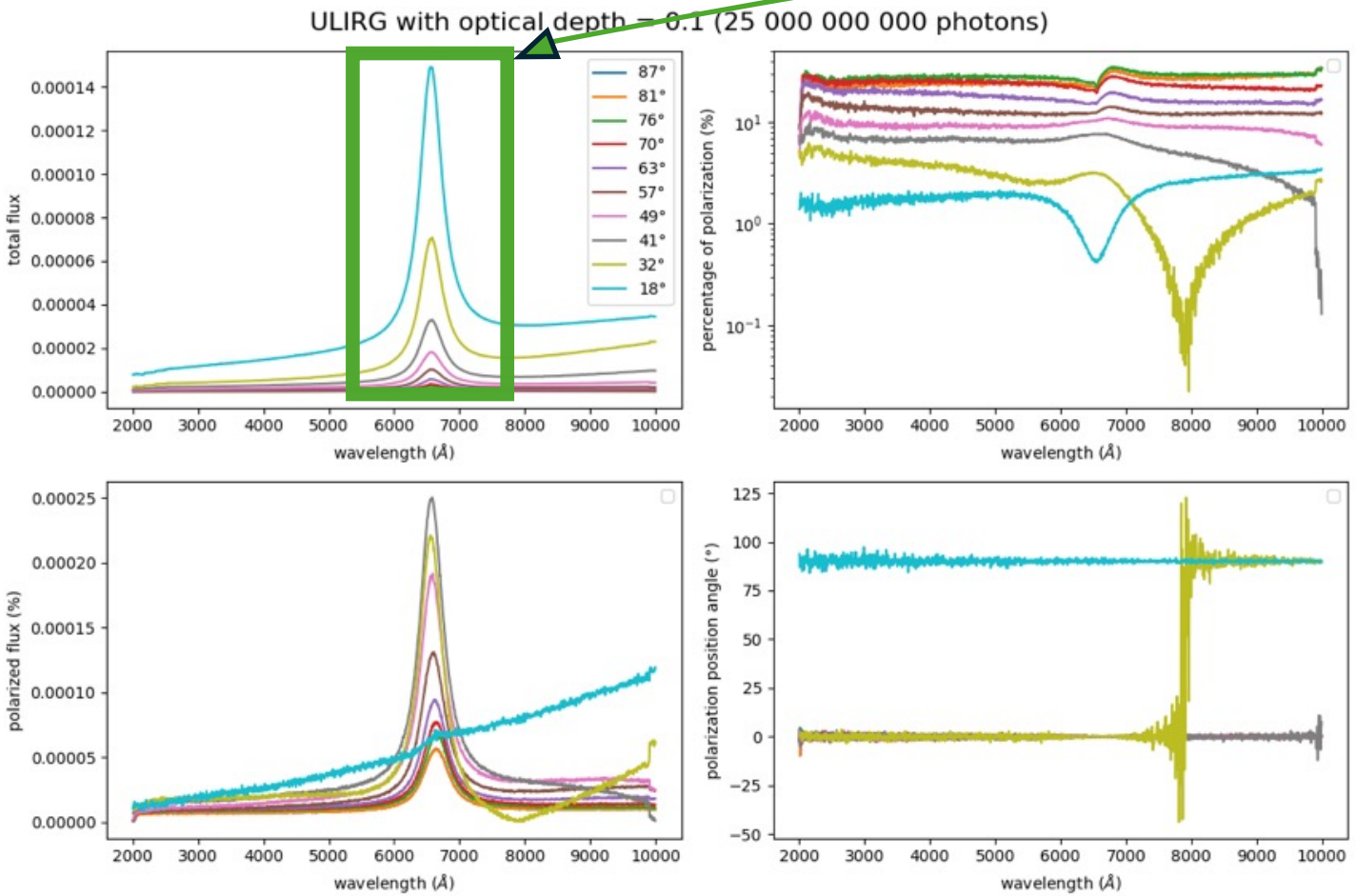


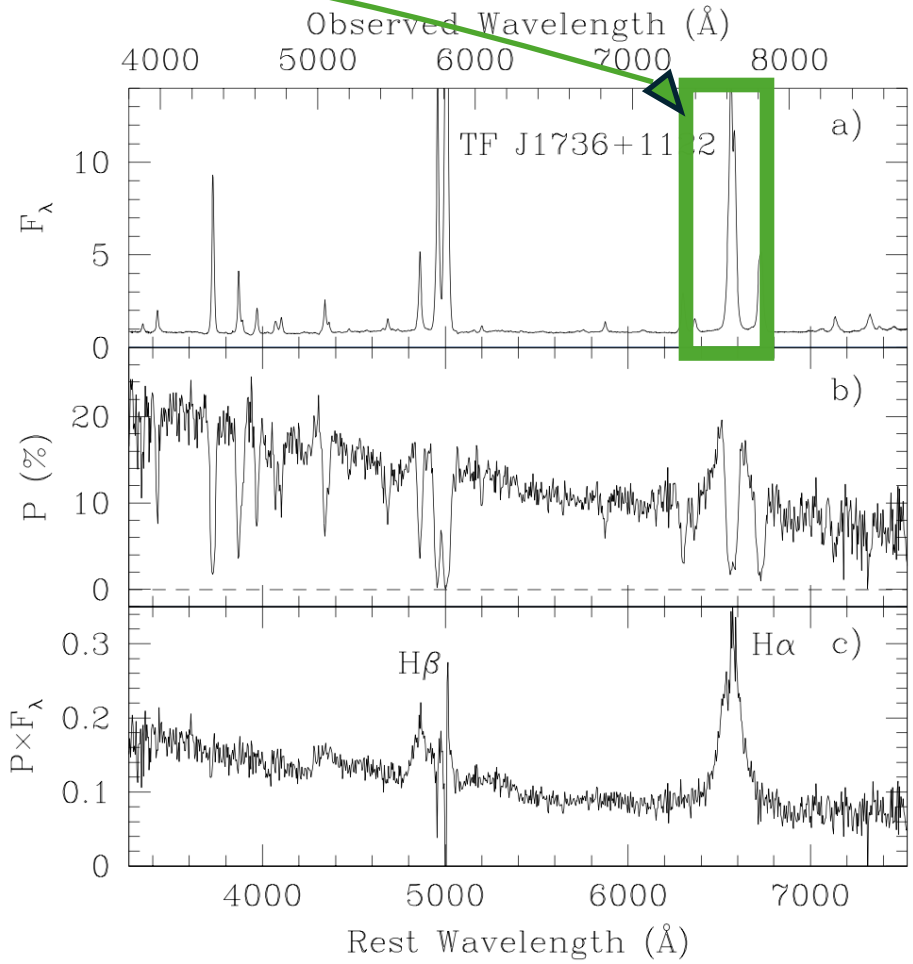


Hien D. Tran, Astrophysical journal, arXiv:astro-ph/9812110v1

Simulation VS Observation

Emission line

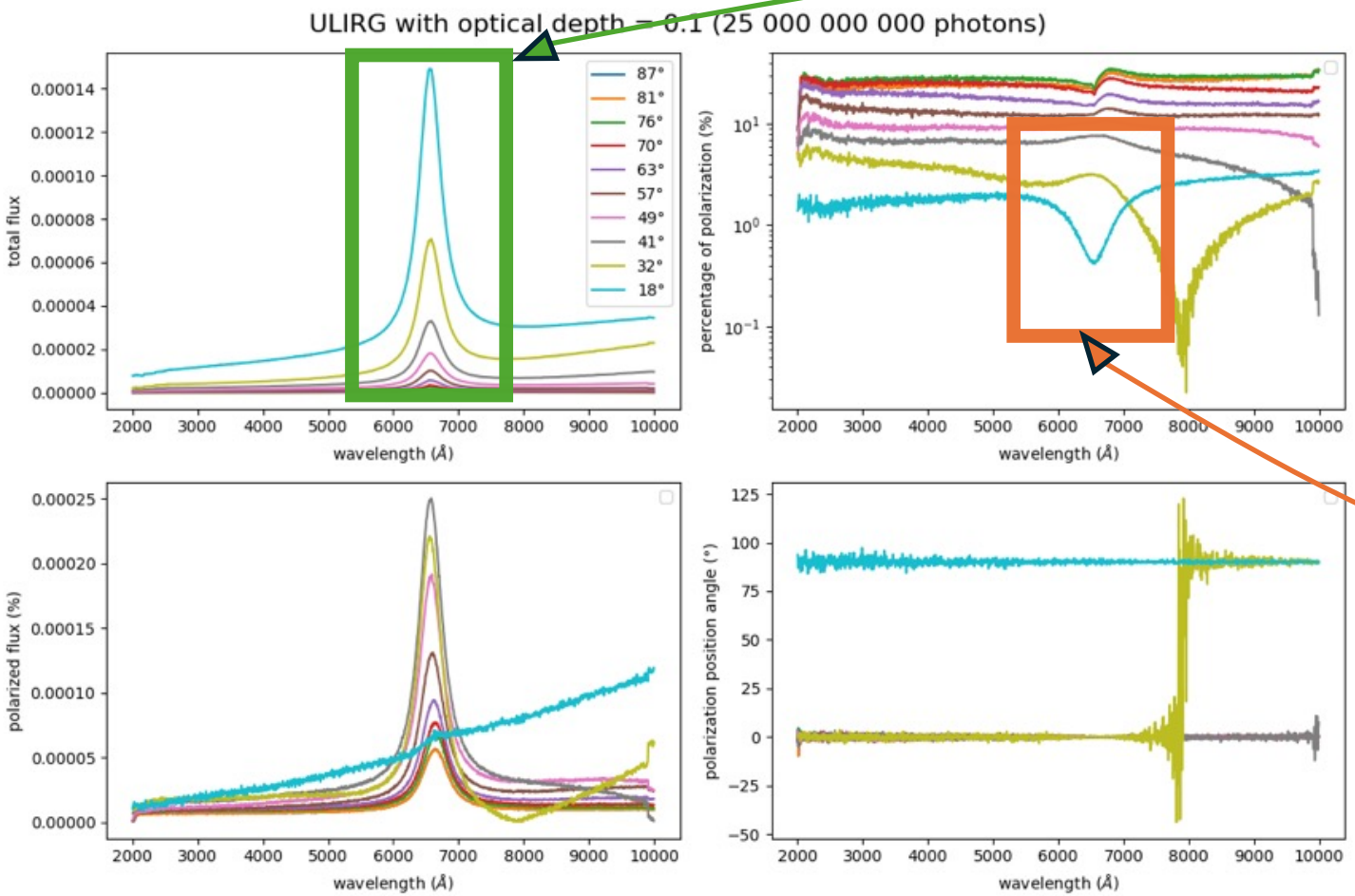


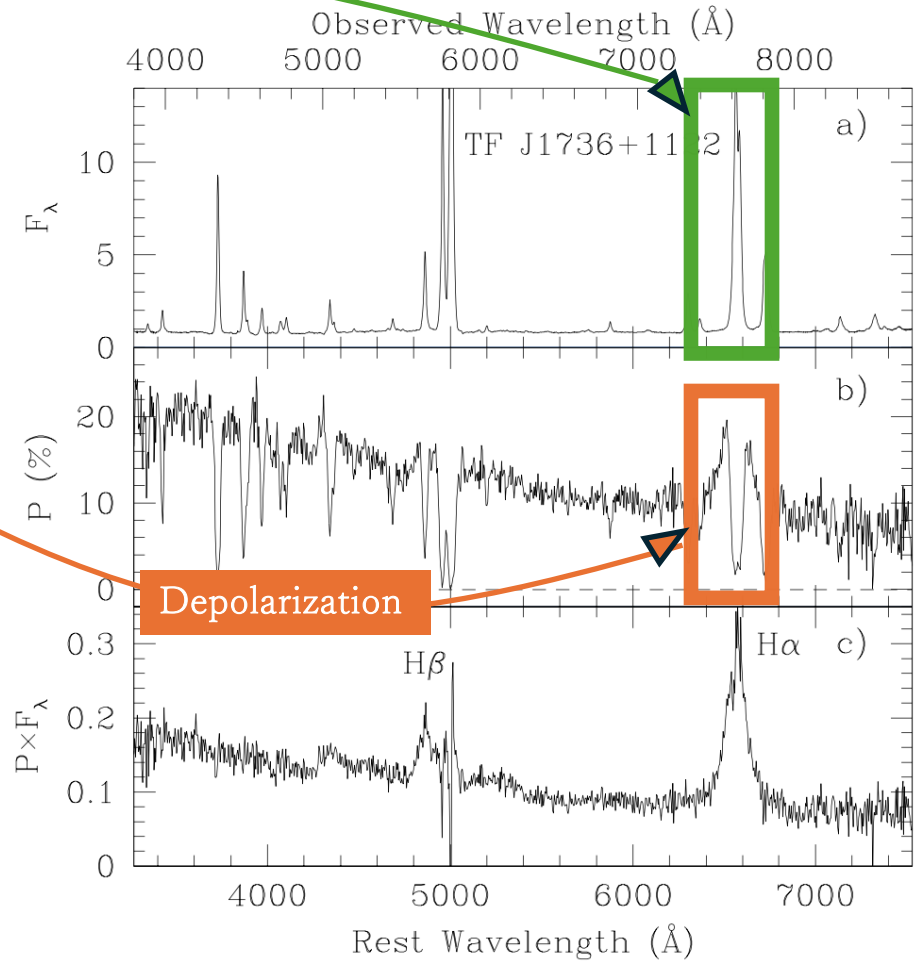


Hien D. Tran, Astrophysical journal, arXiv:astro-ph/9812110v1

Simulation VS Observation

Emission line



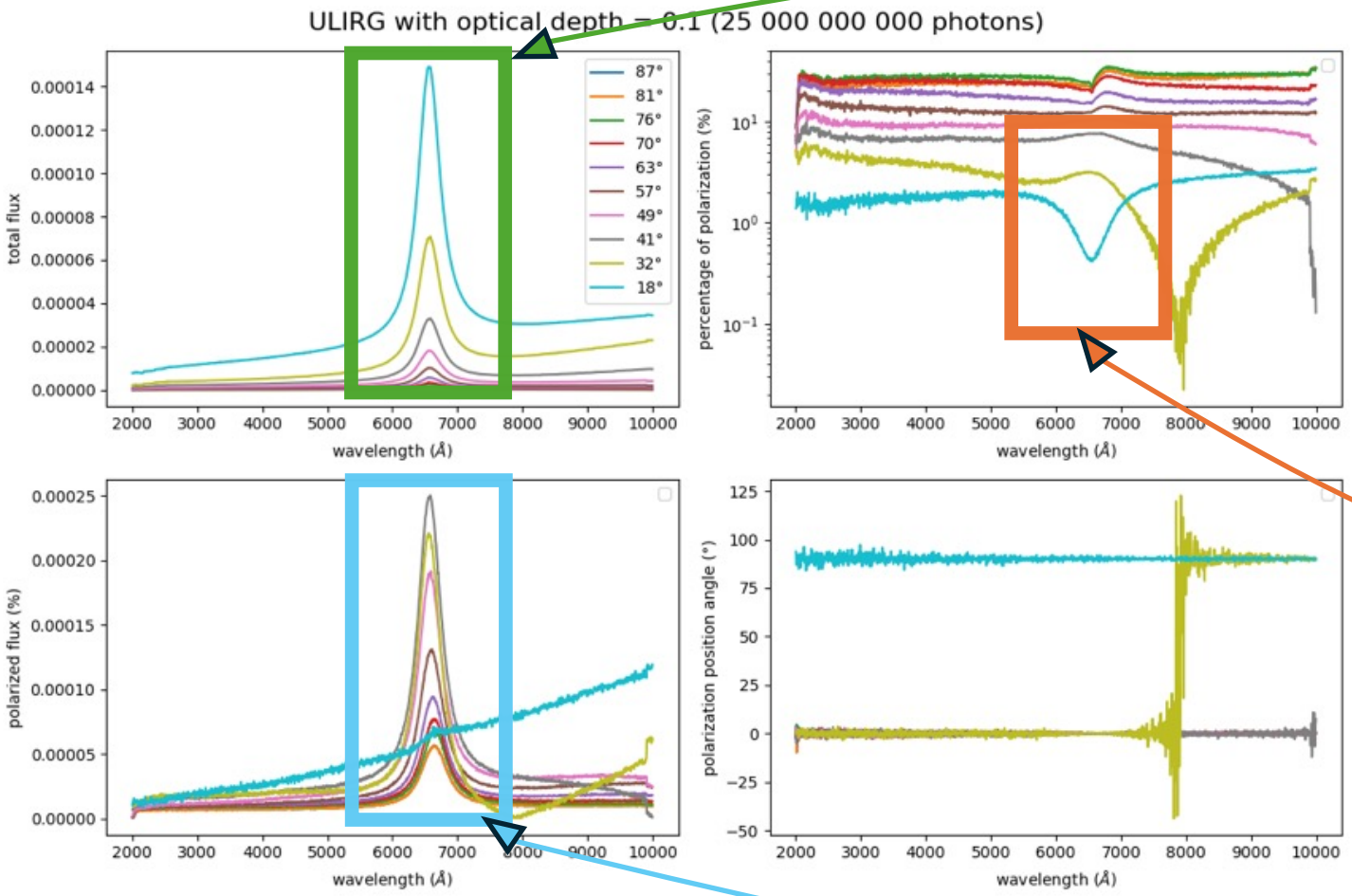


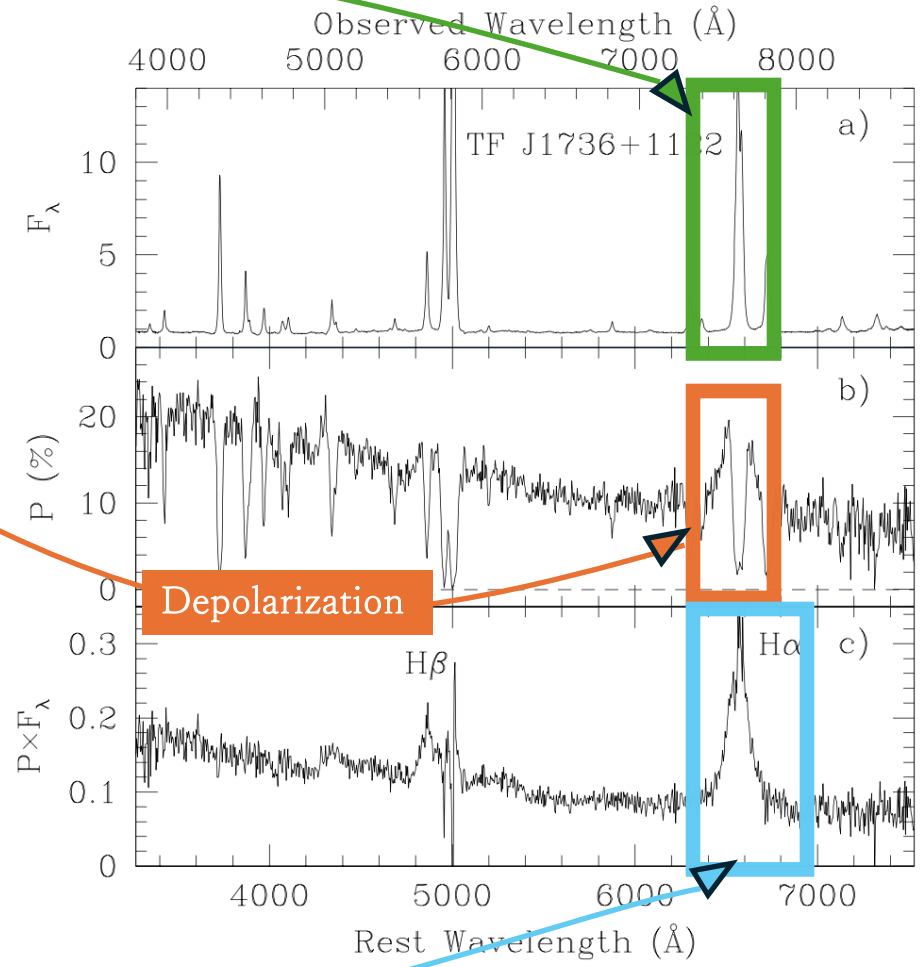
Depolarization

Hien D. Tran, Astrophysical journal, arXiv:astro-ph/9812110v1

Simulation VS Observation

Emission line





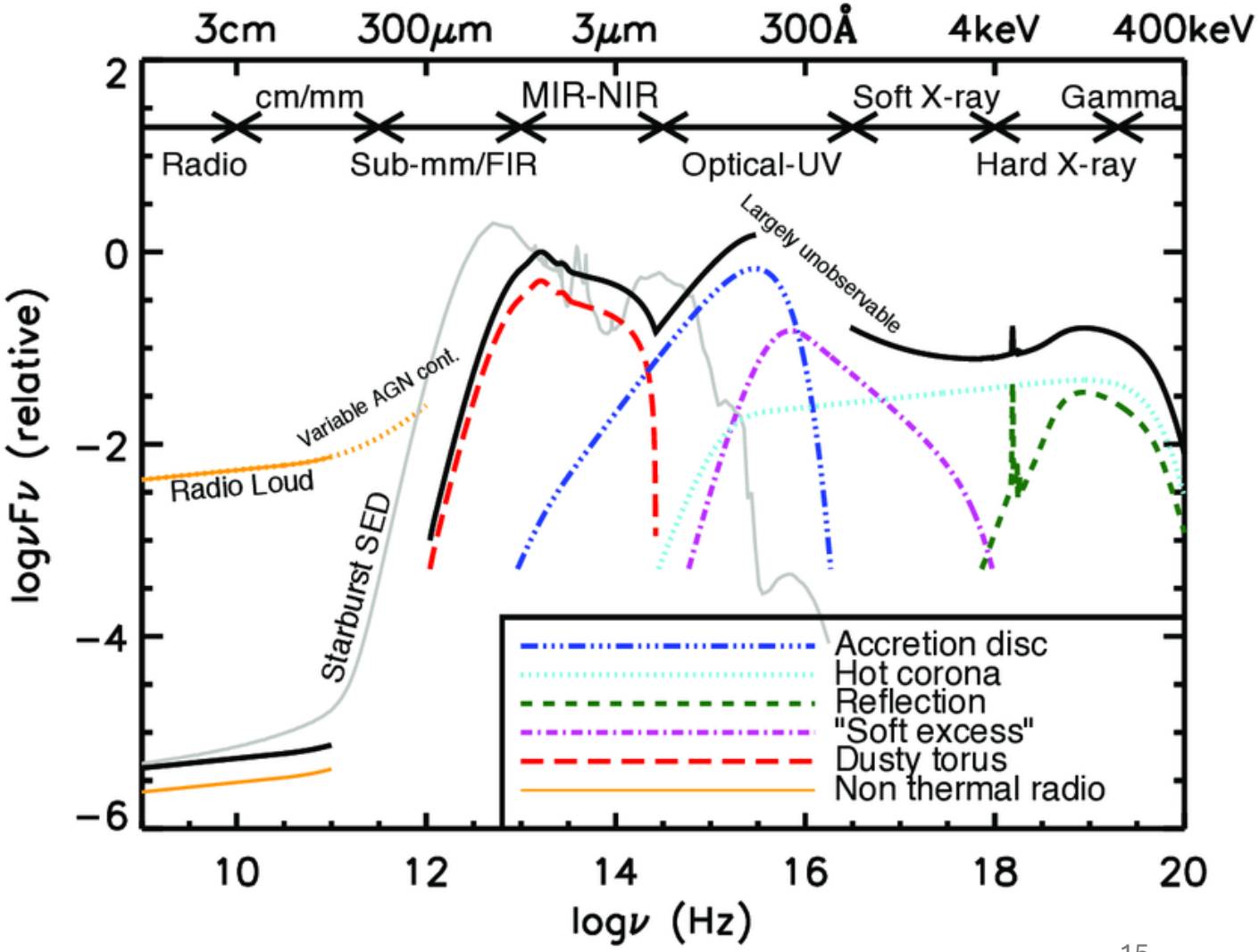
Depolarization

Broad line

Summary & Prospects

- What's an AGN?
- The advantages of spectropolarimetry
- Discovery of a radiative transfer code
- IR contribution

→ Then there's re-emission to add !

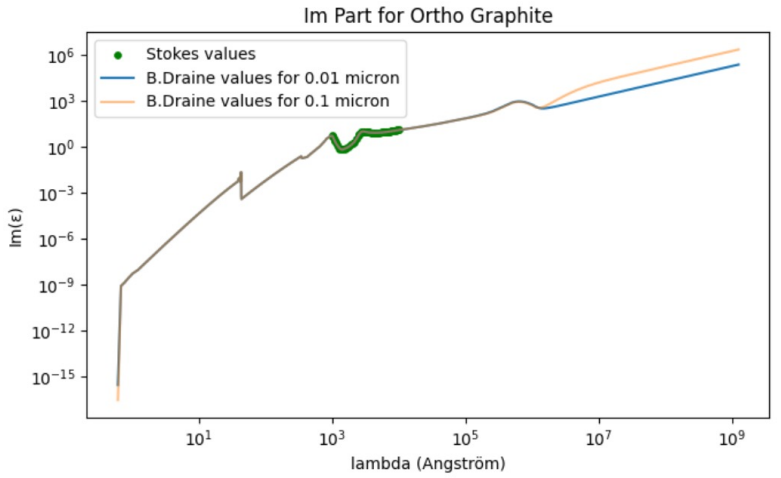


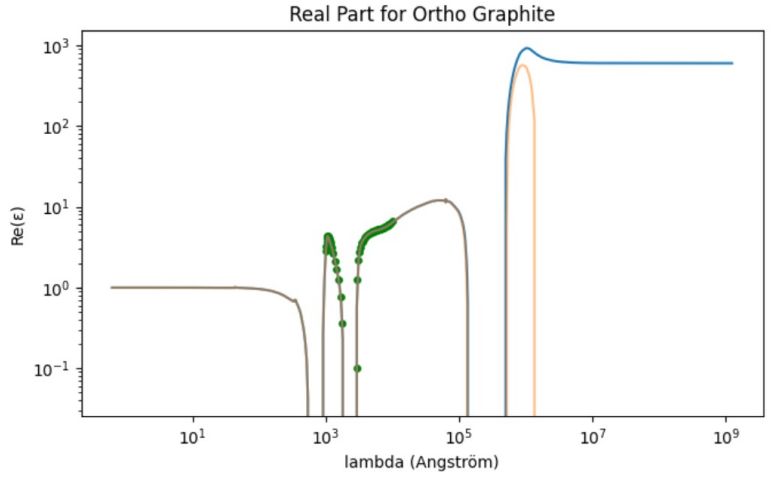
P. Padovani, The Astronomy and Astrophysics Review, Vol 25, p. 310, 2017

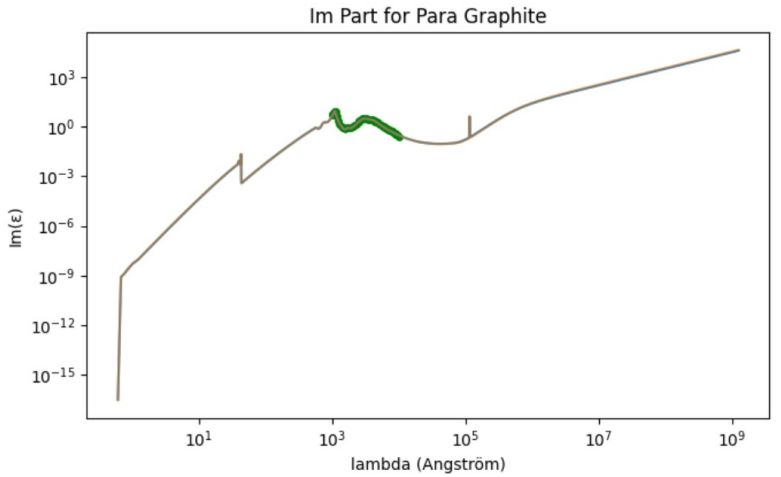
Graphite dielectric function

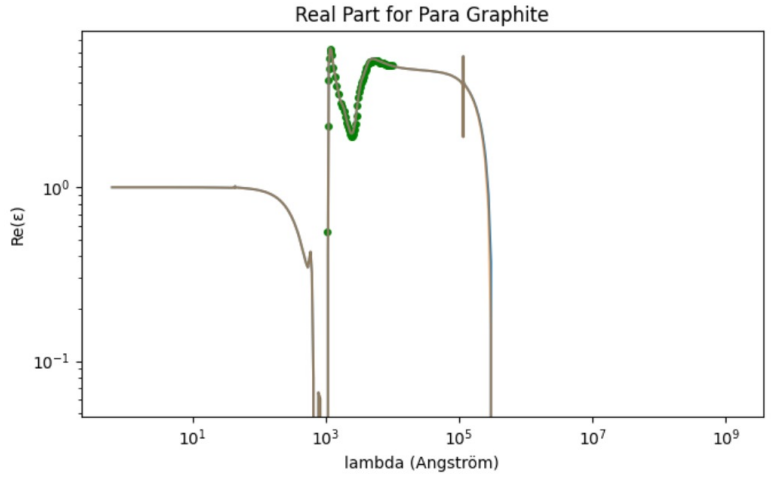
For **graphite** : 2 dielectric functions (parallel & perpendicular)

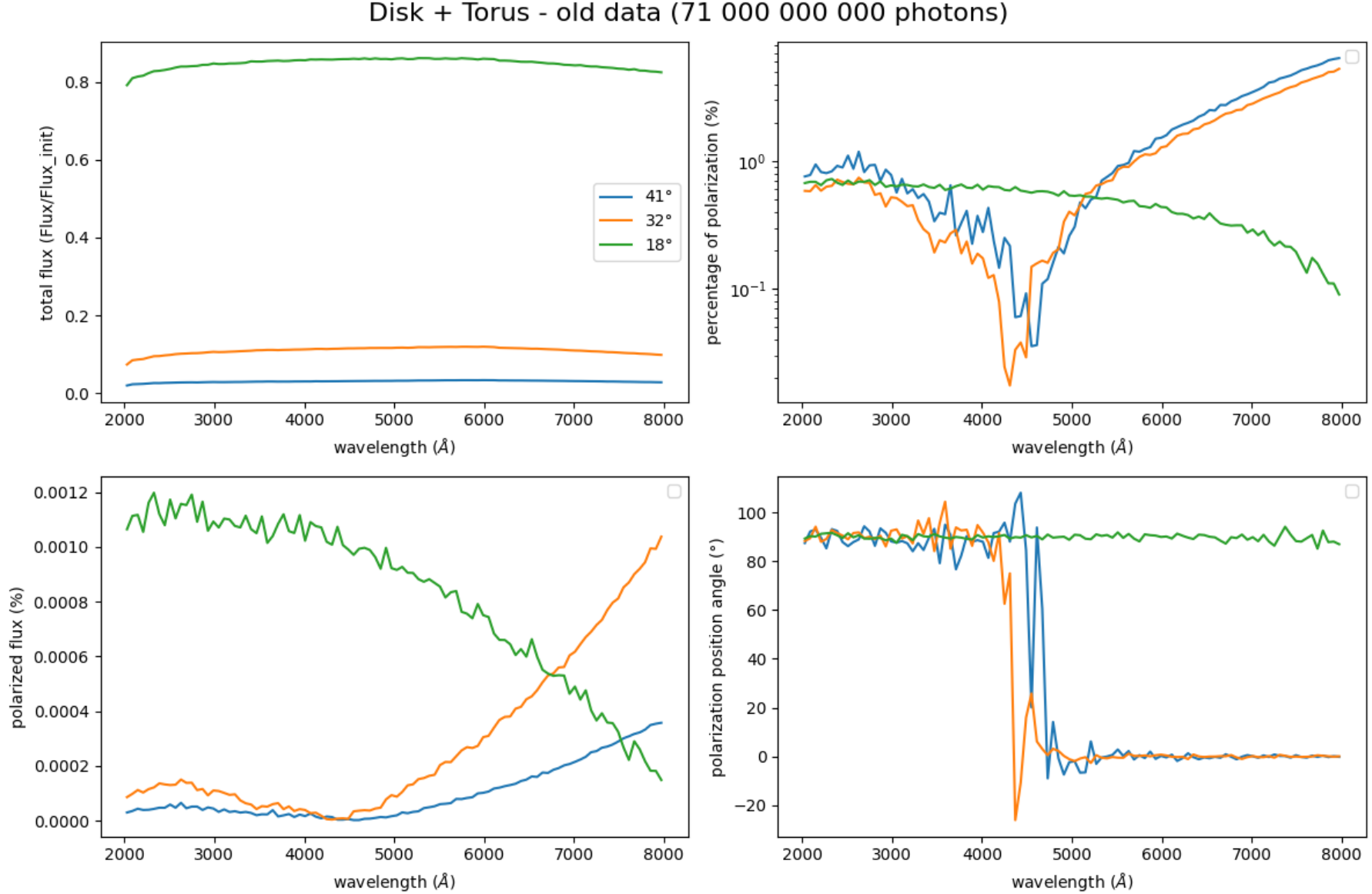
→ Related to the way electrons move through its crystal layers. Give different dielectric responses depending on the orientation of the electric field.

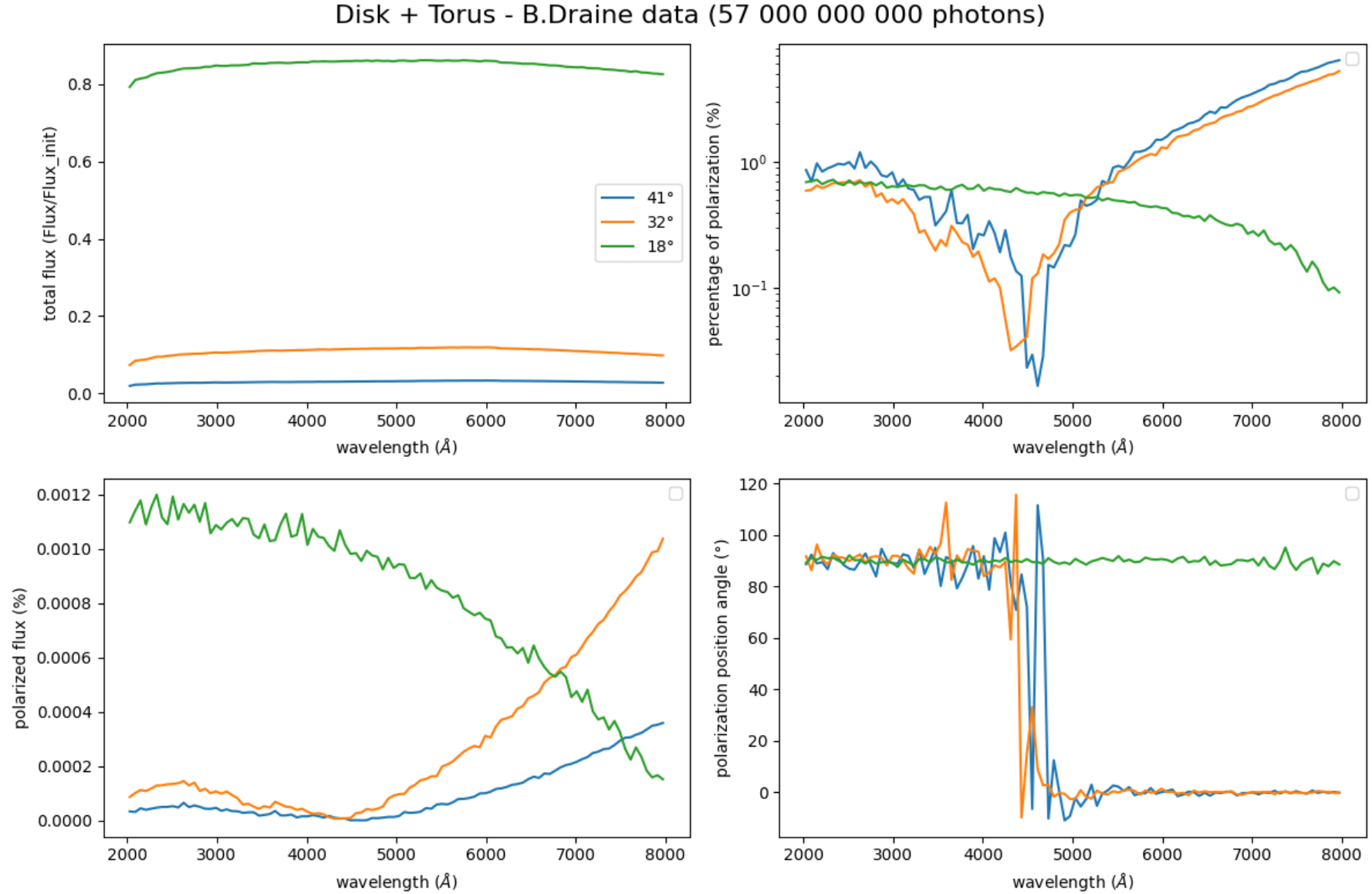









Disk + Torus - old data (71 000 000 000 photons)
total flux (Flux/Flux_init)
wavelength (Å)
41°
32°
18°
percentage of polarization (%)
polarized flux (%)
polarization position angle (°)


Disk + Torus - B.Draine data (57 000 000 000 photons)
total flux (Flux/Flux_init)
wavelength (Å)
41°
32°
18°
percentage of polarization (%)
wavelength (Å)
polarized flux (%)
wavelength (Å)
polarization position angle (°)
wavelength (Å)

+ ULIRG

Defining scattering region :

- Electron disk (same as the continuum emission region)
- Optically thin electron cones
- Optically thick dusty cones (same as NLR)
- Optically thick dusty torus

Defining emission region :

- Continuum emission region
- Double-conically shaped narrow emission line region
- Cylindrical Broad emission line region

And... an optically thick dust shell with 3 different optical depth (0.1, 1 and 10)