Prospects for High-Energy Polarimetry of Blazars: The Big Blue Bump

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Based on: Dreyer & Böttcher (2021: ApJ, 910, 2)

Quasar 3C175
VLA 6cm image (c) NRAO 1996

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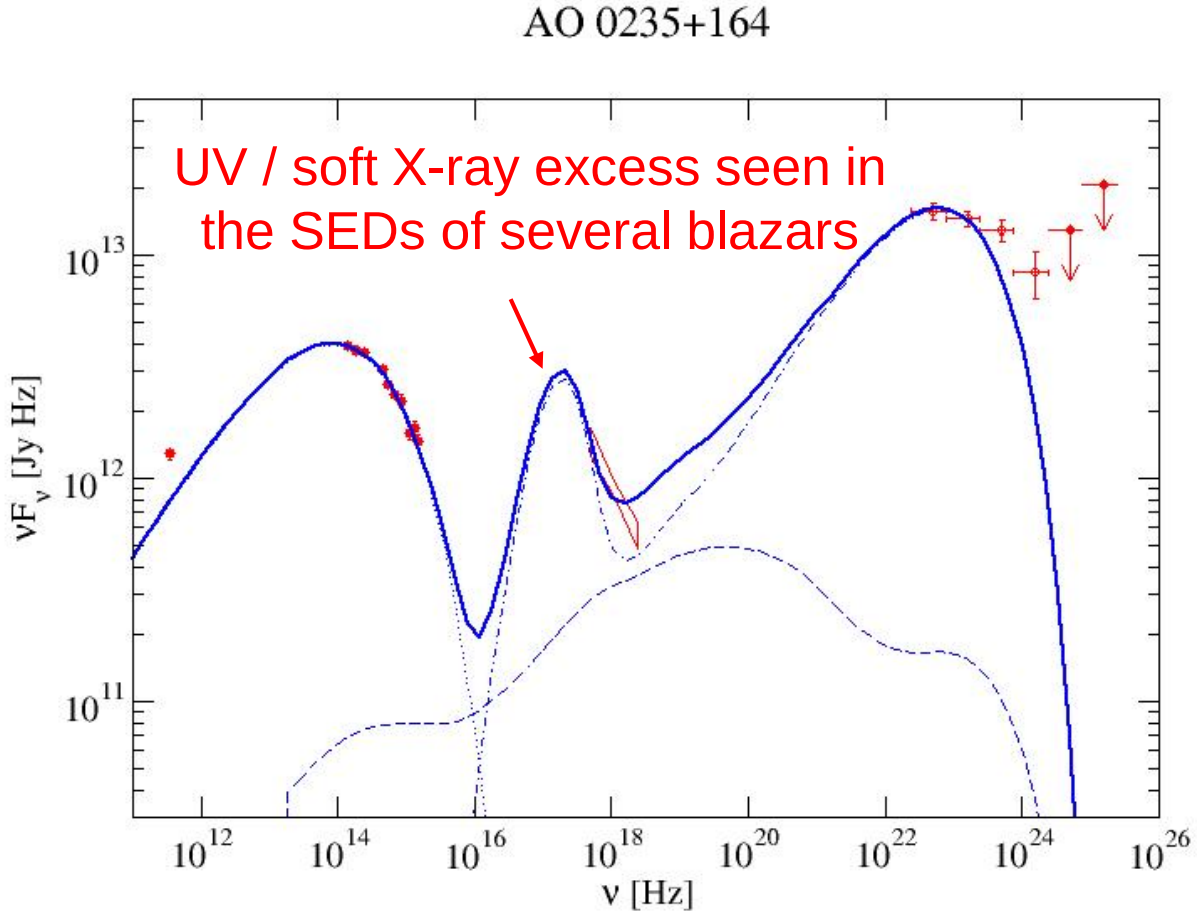
The “Big Blue Bump”



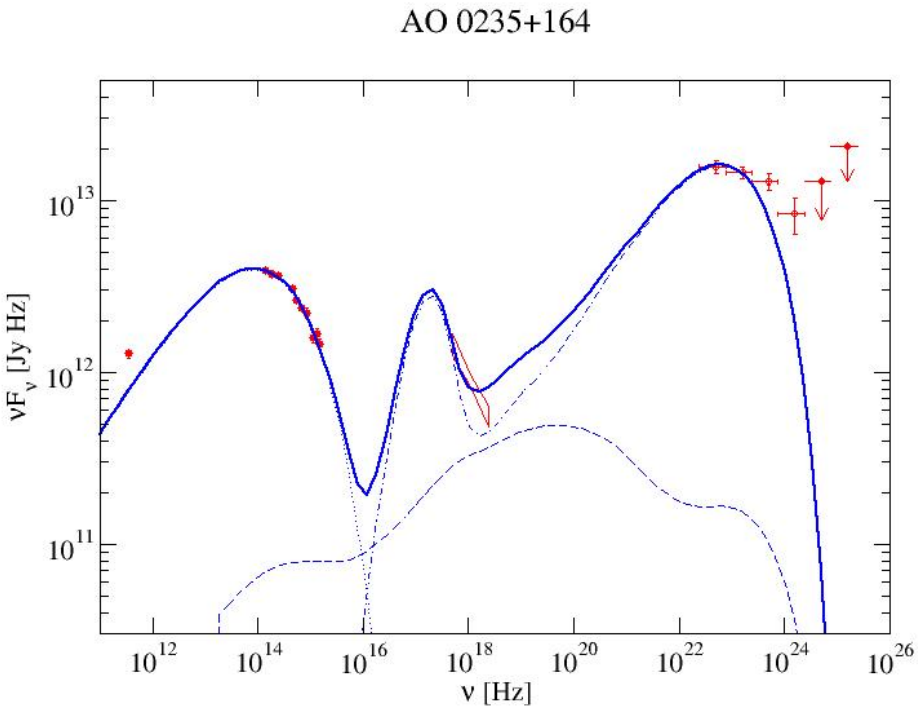
(Baring et al. 2017)

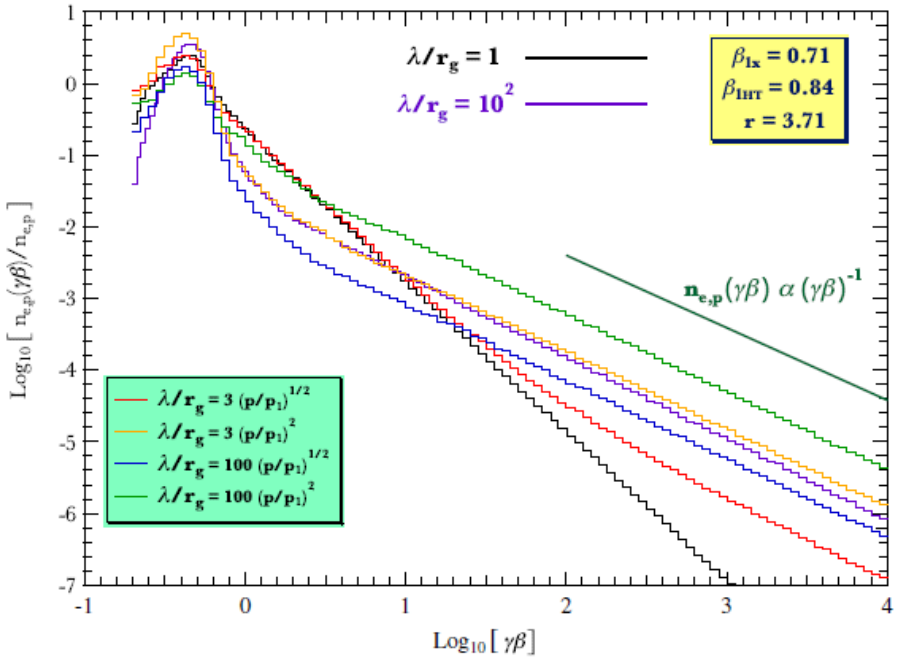
- Accretion disk + Corona? → **Unpolarized**
- Additional synchrotron component? → **Moderately polarized**
- Bulk Compton scattering of external radiation field by thermal electrons (Sikora et al. 1994) → **Potentially highly polarized**

The “Big Blue Bump”

In Baring et al. (2017: MNRAS, 464, 4875):

- Self-consistent thermal + non-thermal electron distributions from diffusive shock acceleration (Summerlin & Baring 2012)
- BBB resulting from Comptonization of external (dust torus) radiation field by the thermal electrons.
- Tight constraints on plasma parameters (total density, magnetization, …)





Compton Polarization

Compton cross section is polarization-dependent:

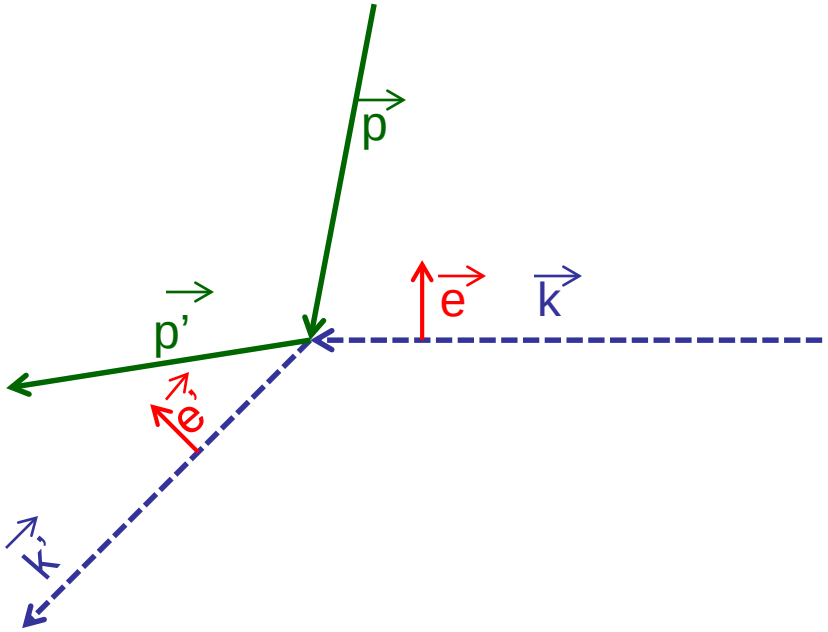
$$\frac{d\sigma}{d\Omega} = \frac{r_0^2}{4}\left(\frac{\epsilon'}{\epsilon}\right)^2\left(\frac{\epsilon}{\epsilon'} + \frac{\epsilon'}{\epsilon} - 2 + 4\left[\vec{e}\cdot\vec{e}'\right]^2\right)$$

$\varepsilon = h\nu/(m_e c^2)$:

Thomson regime: $\varepsilon \approx \varepsilon'$
$\Rightarrow d\sigma/d\Omega = 0$ if $\vec{e}\cdot\vec{e}' = 0$

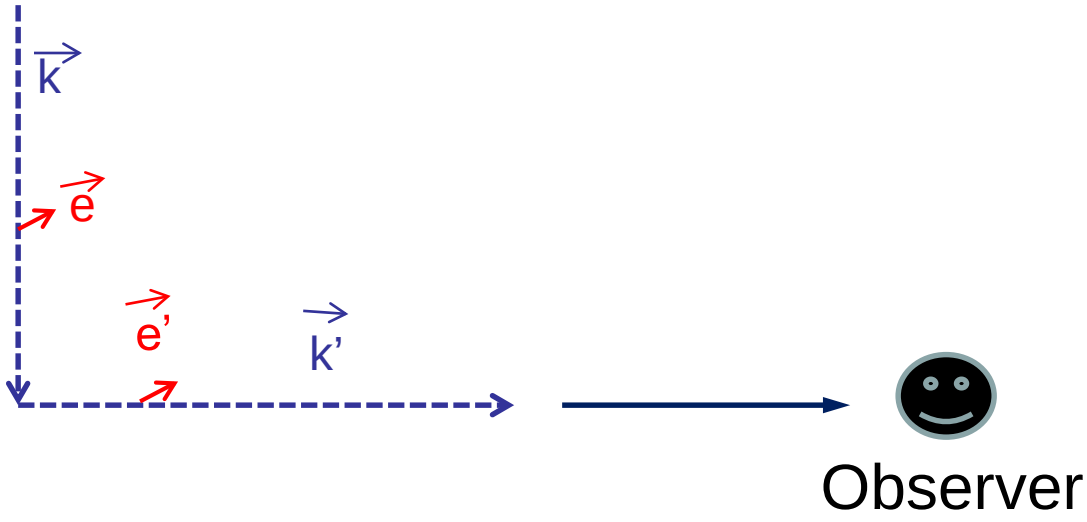
$\Rightarrow$ Scattering preferentially in the plane perpendicular to $\vec{e}$!

Preferred polarization direction is preserved.



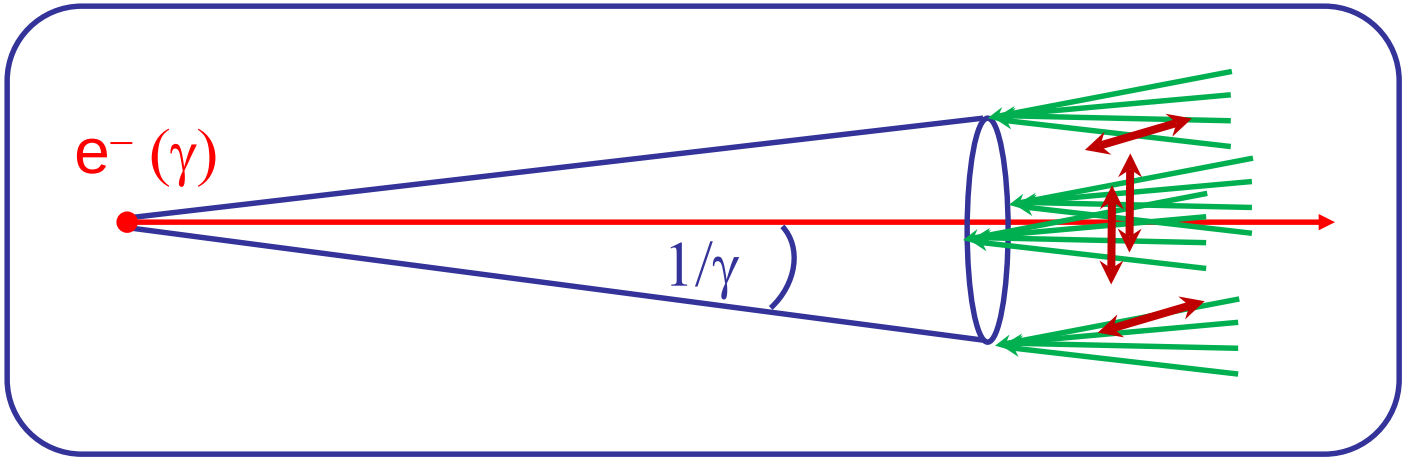
Compton Polarization

Compton scattering of an anisotropic radiation field by **non-relativistic** electrons induces polarization perpendicular to the plane of scattering.



Compton Scattering by Relativistic Electrons

- Relativistic aberration => approx. axisymmetric radiation field in co-moving frame of e^-



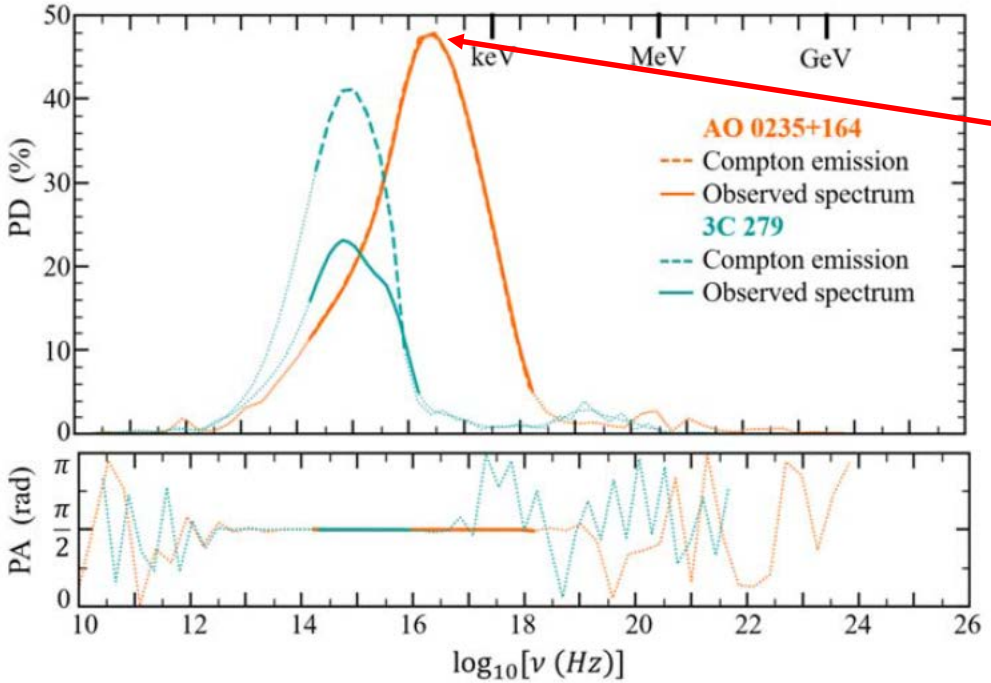
- Unpolarized target photons (EC emission) → **Unpolarized**

- Polarized target photons (SSC) → **SSC polarization ~ ½ of target (synchrotron) photon polarization**

Monte-Carlo Simulations of Polarization-Dependent Compton Scattering

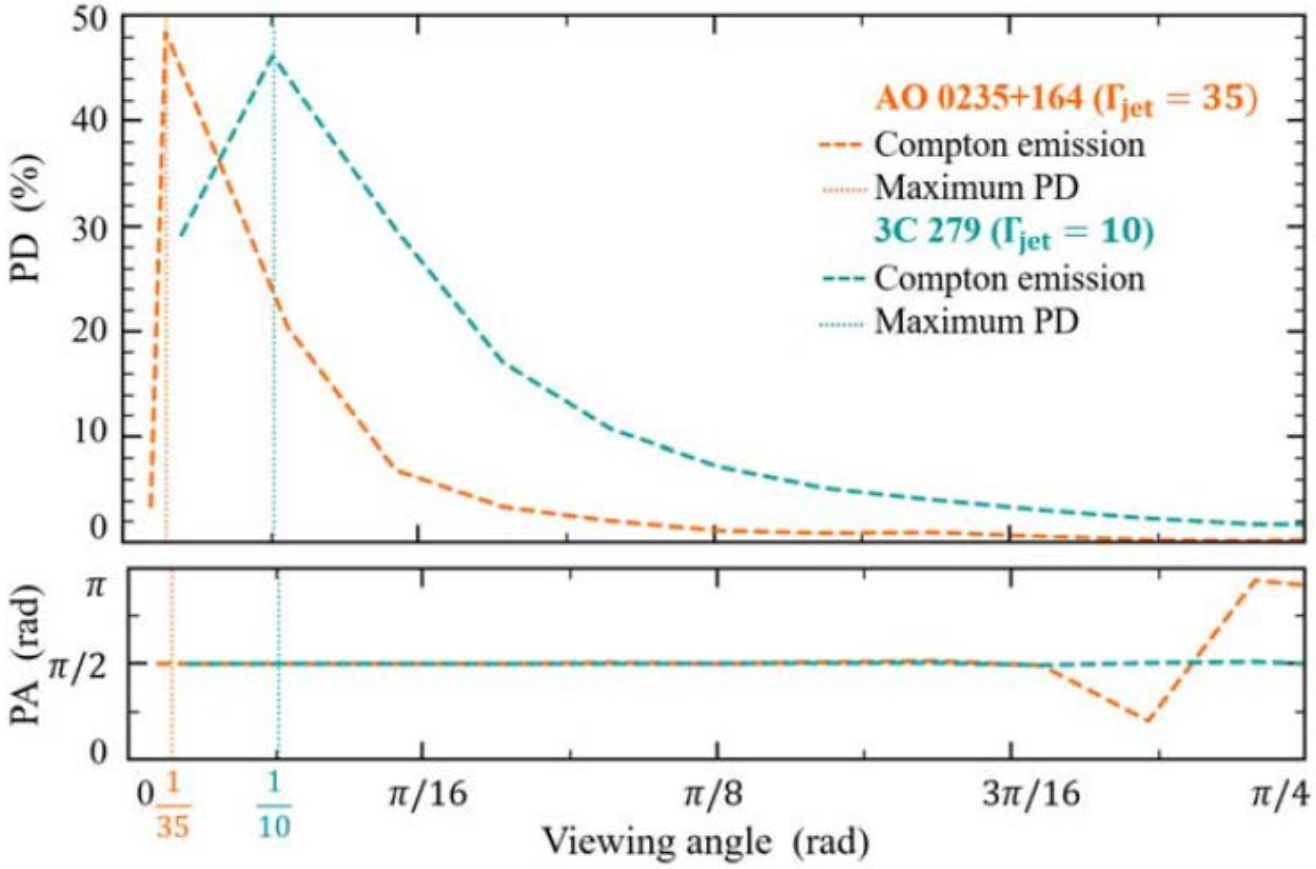
The MAPPIES (Monte-Carlo Applications for Partially Polarized Inverse External Compton Scattering) code (Dreyer & Böttcher 2021: ApJ, 906, 18):

- Arbitrary electron distributions in a relativistically moving emission region
- Arbitrary target photon distributions (unpolarized or polarized)
- Polarization-dependent Compton scattering based on techniques developed by Matt et al. (1996)



BBB in AO 0235+164:
Up to ~ 50 % polarized
in soft X-rays

Polarization of the BBB due to bulk Comptonization



- PD is maximum when the jet is viewed at $\theta_{obs} = 1/\Gamma$, corresponding to 90° scattering in the co-moving frame.
- PA is perpendicular to the jet axis.

Polarization of the BBB due to bulk Comptonization

Blazar Case Study	Polarimeter	Frequency Range [$\log_{10}(\nu/\mathrm{Hz})$]	PD (%)
	POLLUX	14.4–15.5	12–30
	LAMP	16.8	43
AO 0235+164	REDSoX	16.7–17.3	30–46
(IR emission from	XPP	16.6–18.3	$\lesssim$46
the dusty torus)	eXTP	17.0–18.3	$\lesssim$40
	IXPE	17.7–18.3	$\lesssim$20
	POLIX	18.0–18.3	$\lesssim$10

Easily within reach of proposed / future UV / X-ray polarimeters.

Summary

- Developed a new Monte-Carlo code for polarization-dependent Compton scattering
- Application to the Big Blue Bump in AO 0235+164:
  - Up to 50 % polarized in soft X-rays, if due to thermal Comptonization of an external radiation field.
  - Should be easily detectable by future X-ray polarimetry missions.
  - Polarization maximum if the jet is viewed at $\theta_{obs} = 1/\Gamma$
  - PA perpendicular to the jet axis.

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Thank you!

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