# High energy polarization in Blazars

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## Outline

- What are blazars
- The blazar sequence
- Jet dynamics and emission mechanisms
- Polarization in Radio, IR and Optical
- Polarization at high energy: Synchro; SSC and EC
- Conclusion and future
  nerspectives

## Blazars



## Blazars



## The blazar sequence

Donato et al. 2002



#### **Emission mechanisms**





#### **Emission mechanisms**



# **Polarization in Radio**

- Core and jet features can be resolved in radio
- Polarization of the core is of order 10%
- Core polarization varies on small timescales. Faraday screens?
- Polarization in jet features increases
- Magnetic field aligned to jet axis (shear effect?)

# **Polarization in IR-optical**

- Core and jet features cannot be resolved
- Polarization larger than in radio (~20%)
- Frequency dependent, high frequencies more polarized (requires two component emission or single complex region; e.g. Bjornsson 1985)
- No Faraday Rotation

# X-ray pola: Synchrotron

- Synchrotron radiation can be highly polarized if B is coherent.
- Maximum non-relativistic polarization is a function of electron index p: Π<sub>max</sub>=(p+1)/(p+7/3)
- Relativistic aberration reduces maximum polarization in a conical jet

#### **Relativistic correction**



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#### Cancellation depends on spectrum



# X-ray pola: SSC

- Synchroton photons upscattered by IC on the same electrons
- The effect is de-polarizing and introduces dependence on angle (Poutanen 1994)
- Yet sizable polarization can be observed depending on configuration of B

# X-ray pola: SSC



# X-ray pola: External IC

- Photons from the disk randomized by BLR upscattered by IC on the jet electrons
- Radiation highly polarized if electrons are cold (Begelman & Sikora 1987)
- If electrons are even moderately hot, polarization is washed out because of loss of unique scattering geometry (Poutanen 1994)
- As for synchro, relativistic effects depolarize also cold electrons (DL et al. 2003)

# X-ray pola: External IC



# X-ray pola: External IC



DL et al. 2003

## The blazar sequence

Donato et al. 2002



# Summary & Conclusions

- Polarization of Blazars in the X-rays depends on dominant emission mechanism
- Synchro should have same polarization properties as optical. Weak blazars should be polarized
- SSC is less polarized than synchro but could have up to ~10% polarization (Intermediate blazars?)
- EC is unpolarized => polarization is a test for emission mechanism at high to very high energies