Radiation modeling in GRBs and AGN

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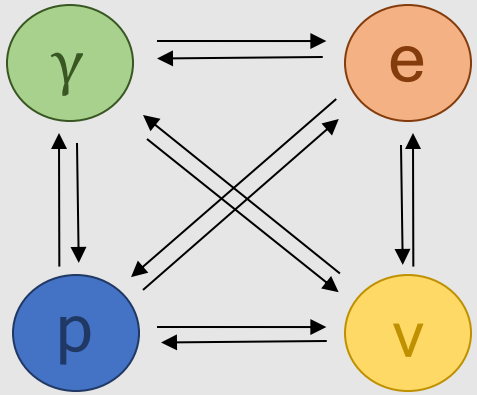
DESY.

Time-dependent radiation modeling in high-energy astrophysical phenomena

Concept: Describe the evolution of particle (density) distributions with coupled partial differential equations (PDEs). Numerically solve PDEs to predict observed spectra.



$$\frac{\partial N_i(E)}{\partial t} = \frac{\partial}{\partial E}\left(-b(E)\, N_i(E)\right) - \frac{N_i(E)}{t_{\mathrm{esc}}} + Q_i(E) + Q_{ji}(E)$$

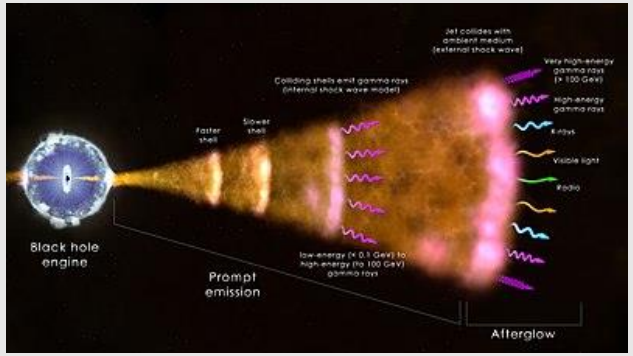
In principle same type of PDEs for different astrophysical objects, only small differences in the processes to account for.

***Different sources*:** Need to model the source with its parameters and dynamics (eg. size of region, Lorentz factor, magnetic field and their temporal evolution)

Two potential sources of high-energy neutrinos and ultra-high energy cosmic rays

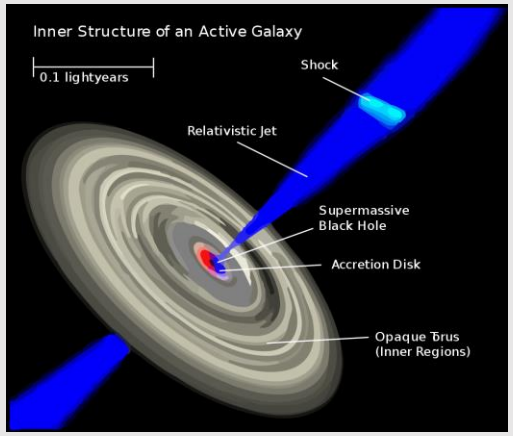
Gamma-Ray Busts (GRBs)

- **Prompt phase** of short, energetic gamma-ray flash, long-lasting afterglow
- short GRBs (< 2s), progenitor merging NS/BH
  long GRBs (> 2s), progenitor Hypernova



Active Galactic Nuclei (AGN)

- Supermassive black hole in center of galaxy
- Particle acceleration in relativistic jet



Can cosmic-ray nuclei reach the highest energies in these sources? How do cosmic-ray signatures shape the electromagnetic SED? How robust are our theoretical predictions?

Current & past Projects (I) - GRBs

I. Leptonic multi-collision models for low-luminosity GRB prompt spectra

What is the impact of the magnetic field strength on the observed prompt spectra? Under which circumstances could we see a high-energy component observable with IACTs? What are the maximal energies attainable for nuclei and the implications for UHECR models?

II. Systematic parameter scan of GRB engines describing the UHECR spectrum

Which engine realisations can describe the measured UHECR spectrum? How can neutrino limits and observed light curves be used to discriminate between fits?

arxiv 2006.14301 / submitted to MNRAS

III. The impact of the collision model on multi-messenger predictions

How do different collision models impact the predicted neutrino fluxes?

arxiv 1907.10633 / *Astrophys.J.* 893 (2020) 72

Current Projects (II) - AGN

I. The Hadronic Code Comparison Project

What are the numerical uncertainties on the predicted SEDs due to computational choices? How do the results of various numerical approaches compare to analytical estimates?

II. Revisiting radiative signatures of heavy nuclei in Centaurus A

Can radiative signatures of heavy nuclei explain the high-energy emission observed for Cen A?

Future Projects

Hadronic signatures in GRB prompt spectra

How do hadronic signatures shape the spectra and light curve in a more refined multi-collision model? Is the baryonic loading suggested by UHECR fits compatible with SED models?

New ideas/ interested in more details? --> annika.rudolph@desy.de