Searches for spectral upturns due to photon to Axion-like particle (ALP) conversions

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GAMMA RAY PROPAGATION AND AXION-LIKE PARTICLES

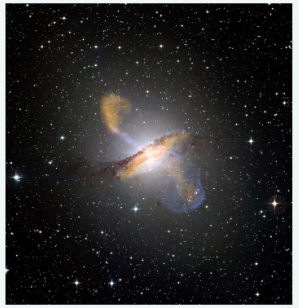
Gamma rays emitted by distant sources attenuated at highest energies ($E_\gamma > 100\,\mathrm{GeV}$) due to **extragalactic background light** (EBL).

Axions / Axion-like particles (ALPs): beyond Standard Model particles originally introduced as solution to the strong CP problem, possible dark matter candidates. [1-3]

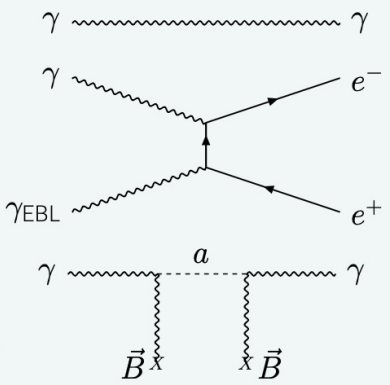
Described by their mass m_a and coupling to the electromagnetic field $g_{a\gamma}$, associated interaction Lagrangian term allows for **photon-ALP conversions**:

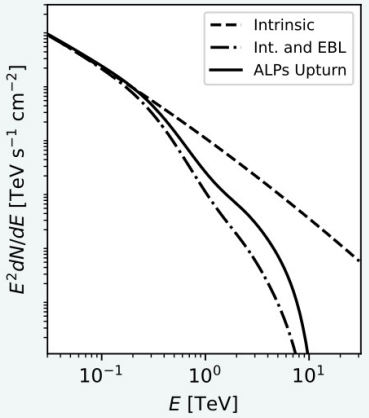
$$\mathcal{L}_{a\gamma} \sim -\frac{1}{4} g_{a\gamma} F_{\mu\nu} \tilde{F}^{\mu\nu} a \qquad (1)$$

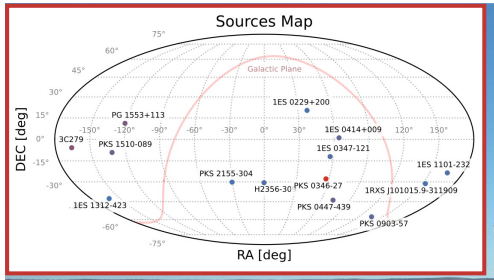
Could partially alleviate EBL attenuation, producing characteristic **spectral upturns**. [4-6]

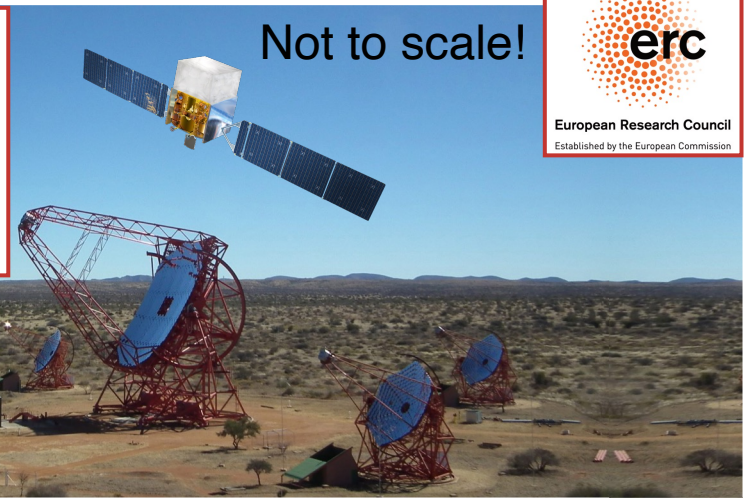


Credits: ESO/WFI (Opt.); MPIfR/ESO/APEX/A.Weiss et al. (Sub-mm); NASA/CXC/CfA/R.Kraft et al. (X-ray).









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Time variability analysis, spectral modeling, upturn searches, ALP simulations, …

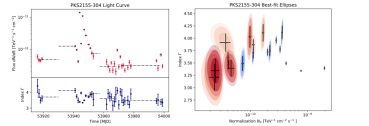

Figure 1. Bayesian-blocked light curve across flux and spectral index, spectral variability best-fit ellipses.

Binned Poisson likelihood-based **intrinsic spectral modeling** with EBL attenuation:

$$\phi_{\mathrm{int}}(E;\theta_{\mathrm{int}} = \{\Gamma, \beta, N_0, E_0\}) \cdot \phi_{\mathrm{EBL}}(E;z) = N_0 \left(\frac{E}{E_0}\right)^{-\Gamma - \beta \log(E/E_0)} \cdot e^{-\tau(E,z)} \qquad (2)$$

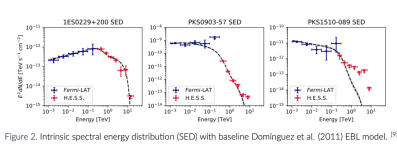

Figure 2. Intrinsic spectral energy distribution (SED) with baseline Domínguez et al. (2011) EBL model. [9]