VERY-HIGH-ENERGY QUASARS HINT AT ALPs?

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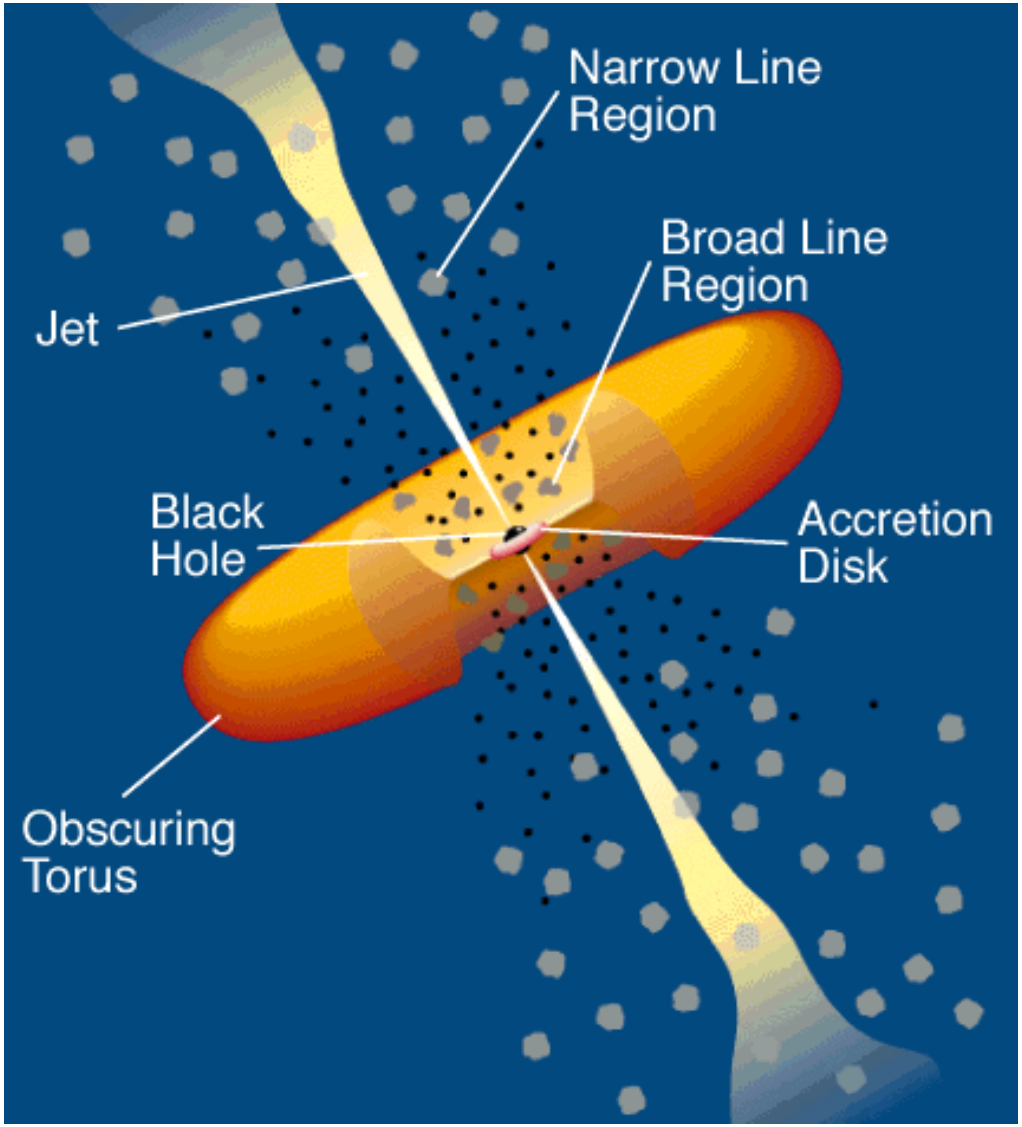
BLAZARS


Narrow Line
Region
Broad Line
Region
Jet
Black
Hole
Accretion
Disk
Obscuring
Torus

Two possible non-thermal emission mechanisms.

- LEPTONIC mechanism (syncro-self Compton): in the presence of the magnetic field relativistic elections emit synchrotron radiation and the emitted photons acquire much larger energies by inverse Compton scattering off the parent electrons (external electrons). the resulting SED (spectral energy distribution) $\nu F_\nu \propto E^2\, dN/dE$ has two peaks: the synchrotron one somewhere from the IR to the X-ray band, while the inverse Compton one lies in the γ-ray band around $50\,\mathrm{GeV}$.

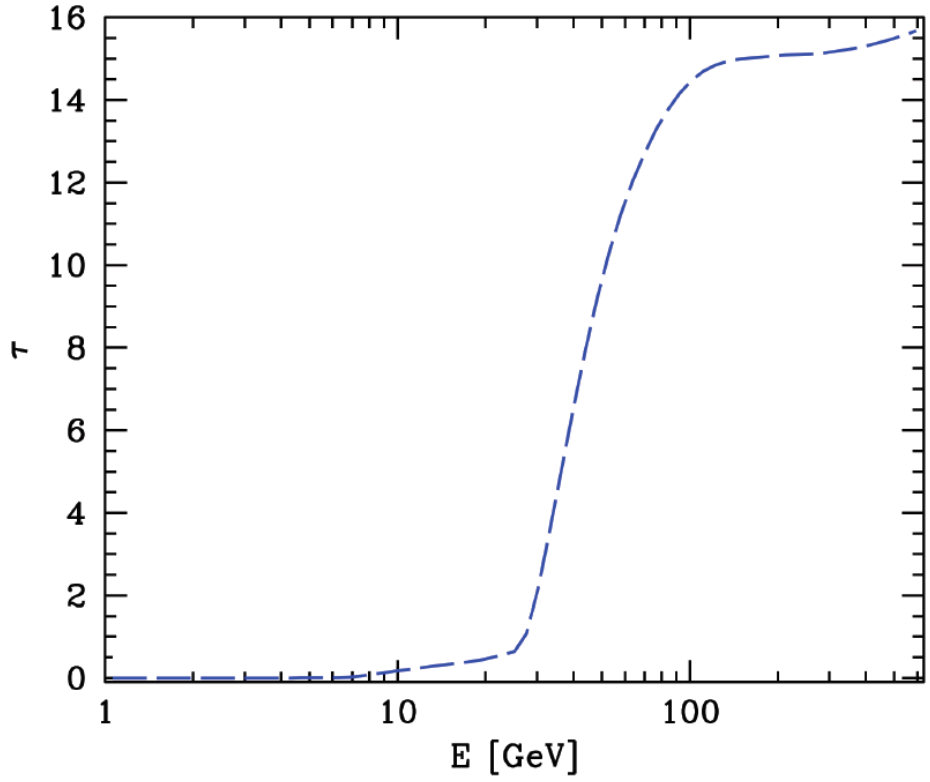
- Hadronic mechanism: same as before for synchrotron emission, but the gamma peak is produced by hadronic collisions so that also neutrinos are emitted.

When the jet is oriented towards us the AGN is called BLAZAR.

There are 2 kinds of blazars:

- BL LACs: they lack broad optical lines which entails that the BLR is lacking.
- FLAT SPECTRUM RADIO QUASARs (FSRQs): they show broad optical lines which result from the existence of the BROAD LINE REGION (BLR) al about 1 pc from the centre.

In the BLR there is a high density of ultraviolet photons, so that the very-high-energy (VHE) photons ($E > 50\,\mathrm{GeV}$) produced at the jet base undergo the process $\gamma\gamma \longrightarrow e^+e^-$. As a result, the FSRQs should be INVISIBLE in the gamma-ray band above $20 - 30\,\mathrm{GeV}$.



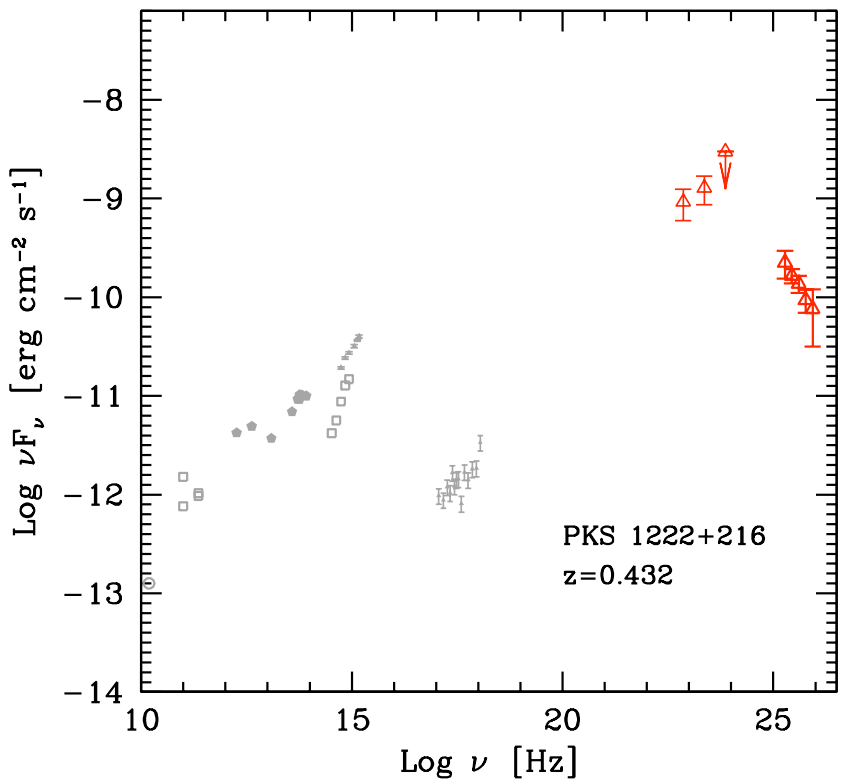
However OBSERVATIONS show that this is NOT TRUE.
At least 5 FSRQs have been observed by Imaging Atmospheric Cherenkov Telescopes (IACTs) in the energy range $100\,\mathrm{GeV} - 1\,\mathrm{TeV}$, and their fluxes are similar to those of the BL LACs!

What is going on?

The most striking case is that of PKS 1222+216 which has been observed SIMULTANEOUSLY by *Fermi*/LAT in the band $0.3 - 3\,\mathrm{GeV}$ and by MAGIC in the band $70 - 400\,\mathrm{GeV}$.

In addition, MAGIC has detected a flux doubling in about 10 minutes which entails that the emitting region has size of about $10^{14}\,\mathrm{cm}$, but the observed flux is similar to that of a BL LAC. So, 2 problems at once!

Red open triangles at high and VHE are the spectrum of PKS 1222+216 recorded by *Fermi*/LAT and the one detected by MAGIC but EBL-deabsorbed according to conventional physics.



Various astrophysical solutions have been proposed, but all of them are totally AD HOC even because one has to suppose that a blob with size $10^{14}\,\mathrm{cm}$ at a distance of more than 1 pc from the centre exists with the luminosity of a whole BL LAC.

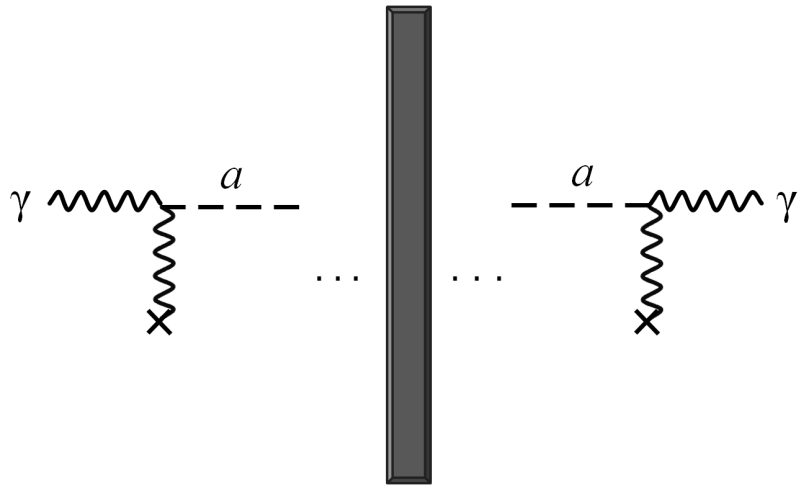
IDEA

Suppose that photons are produced by a standard emission model like SSC at the jet base like in BL LACs, but that ALPs exist. Then

- Photons can become mostly ALPs BEFORE reaching the BLR in the jet magnetic field.
- ALPs can go UNIMPEDED through the BLR.
- Outside the BLR ALPs can reconvert into photons in the outer magnetic field.

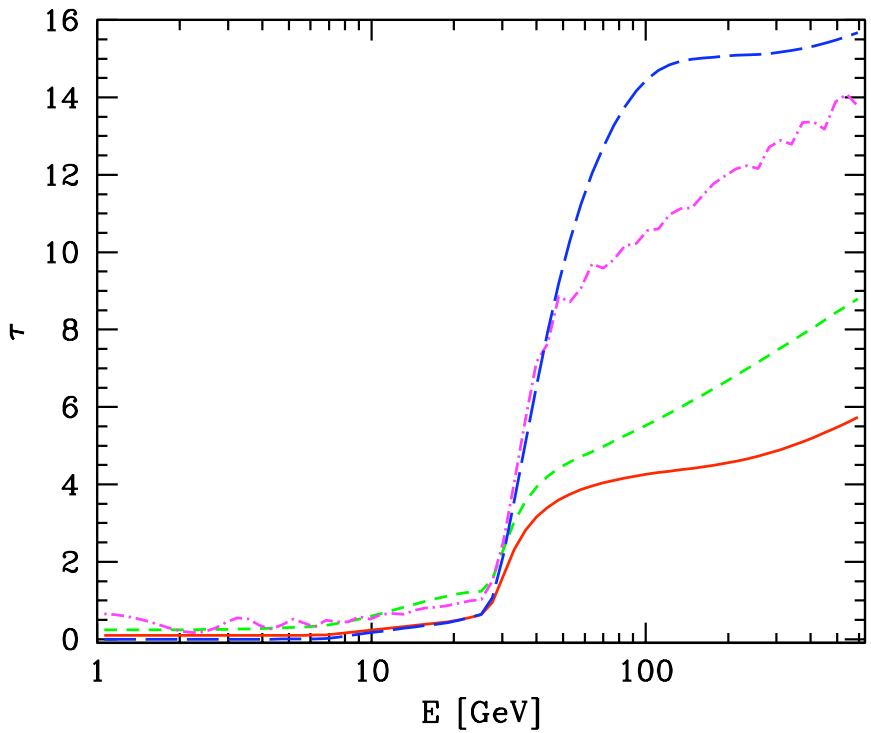
(Tavecchio, Roncadelli, Galanti and Bonnoli, Phys. Rev. D **86**, 085036 (2012))

Schematically

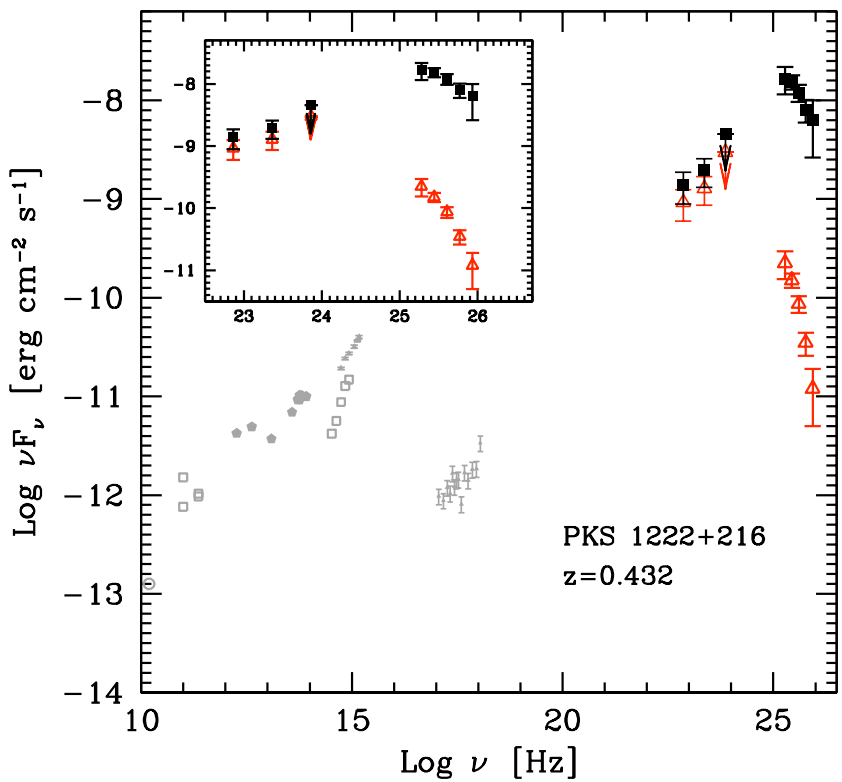


where the vertical bar is the BLR.

After some playing with the parameters we find that the best choice to reduce the photon absorption by the BLR is $B = 0.2\,\mathrm{G}$, $M = 7 \cdot 10^{10}\,\mathrm{GeV}$ e $m < 10^{-9}\,\mathrm{eV}$, which is represented by the RED line



Red open triangles at high energy and VHE are the spectrum of PKS 1222+216 recorded by Fermi/LAT and the one detected by MAGIC but EBL-deabsorbed according to conventional physics. Black filled squares represent the same data once FURTHER corrected for the photon-ALP oscillation effect.

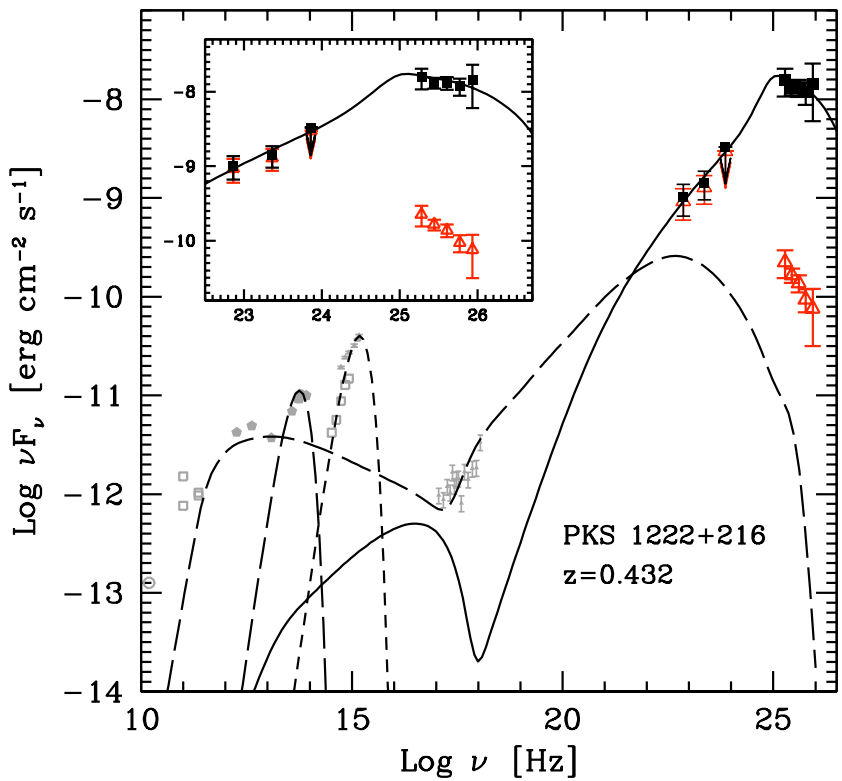


However, this is not enough. We have supposed that photons are produced by a standard emission mechanism. Moreover, PKS 1222+216 has been SIMULTANEOUSLY observed by *Fermi*/LAT and MAGIC. So, we should pretend that the detected photons have a STANDARD SED, namely they should lie on a inverse Compton peak.

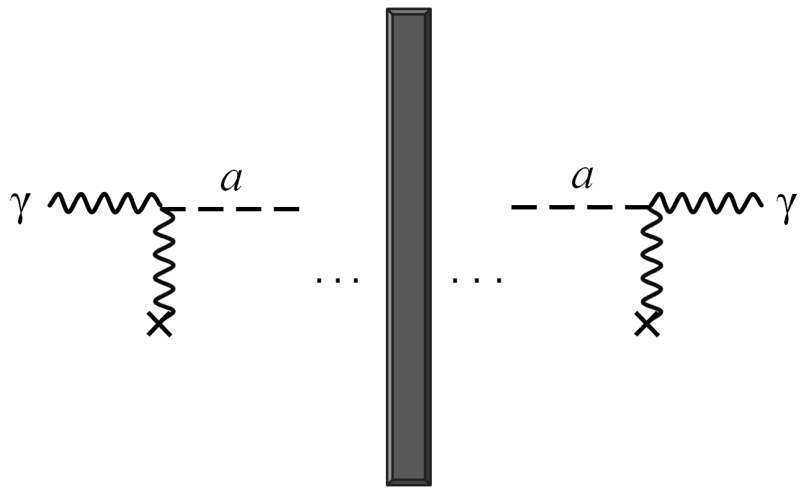
This is by far NOT guaranteed, since in the presence of absorption and one-loop QED effects the photon-ALP conversion probability is E-DEPENDENT.

Nevertheless, a standard two-blob emission model with realistic values for the parameters yields

Red points at high energy and VHE are the spectrum of PKS 1222+216 recorded by Fermi/LAT and the one detected by MAGIC but EBL-deabsorbed according to conventional physics. Black points represent the same data once FURTHER corrected for the photon-ALP oscillation effect. Solid black line is the resulting SED.



Our proposal will be checked by the ALPS experiment at DESY, which will reach the astrophysical important region for M in 2017



where the vertical bar is a normal wall.