Modelling The Virgo B-Field To Find Axion Like Particles

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Brief Overview

What are we attempting?
To Model the Turbulent B-Field of the Virgo Cluster as a Gaussian Turbulent Field to search for **ALPs** in the VHE Gamma ray Spectrum [> 100 GeV].

How do we plan to do it?
Using the open source gammaALPs framework in Python [Meyer et. al. 2021].

Why do we want this?
To search for photon-ALP oscillation with VHE Gamma Rays in Large scale B fields. VHE Gamma Rays will probe ALPS with masses [m: 10 – 1000 neV] and coupling constants [g: 1-10 x 10^{-11} GeV^{-1}].

Axions & ALPs

What are Axions?
They are Pseudo Nambu-Goldstone Bosons which appear from the Spontaneous Symmetry Breaking of the Peccei-Quinn Symmetry, a solution to the Strong CP problem.

How do we look?
We look for signatures of a predicted behavior of the theoretical Axions and ALPs: photon-axion oscillation!

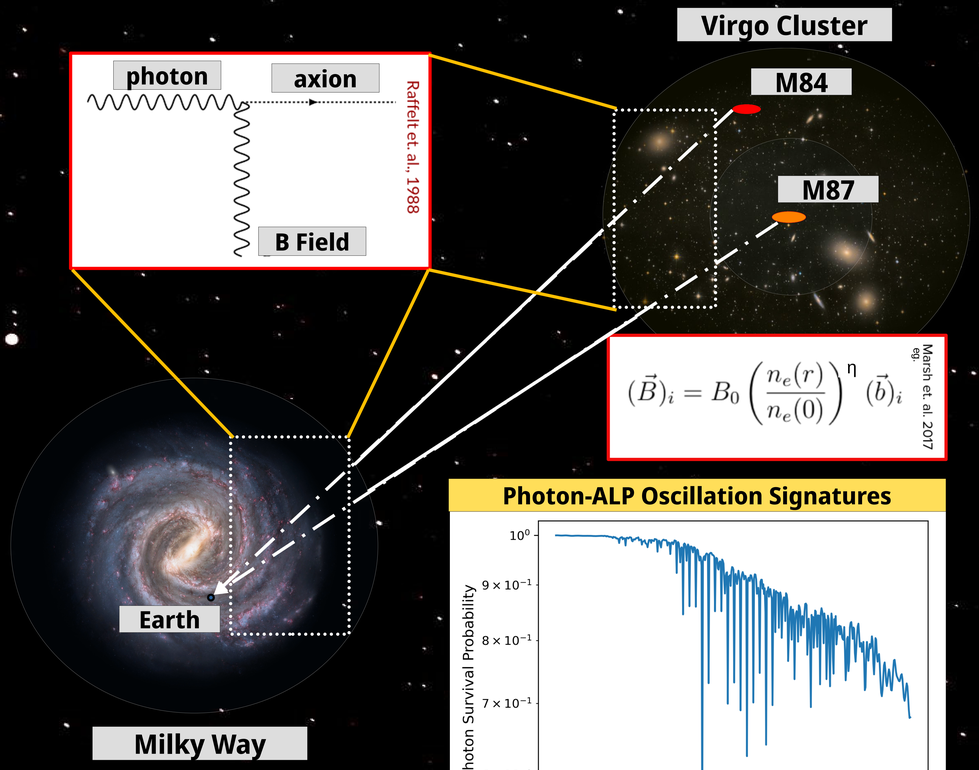
Where do we look?
There is a vast parameter space, a part of which we are attempting to probe using High-Energy Gamma Ray studies.

[Weinberg 1978, Wilczek 1978, Peccei et. al. 1977]

Trivia

While hypothesising the particle, Wilczek coined the term "**Axion**" while Weinberg called it "**Higglet**".

Which one do you prefer?



$$(\vec{B})_i = B_0 \left(\frac{n_e(r)}{n_e(0)}\right)^{\eta} (\vec{b})_i$$

Marsh et. al. 2017 eq.

Our Source: M87

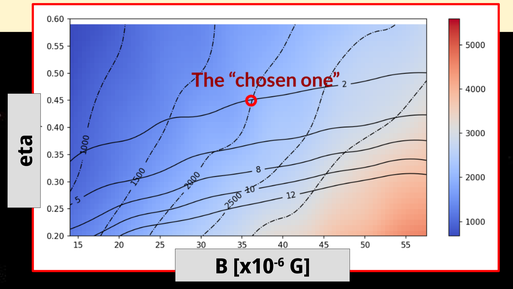
What is it?
M87 or Virgo A is Supergiant Elliptical Galaxy, centrally located in the Virgo Cluster.

Why do we want to use it?
It has an active central SMBH with a collimated jet. It has been observed in flaring states in Gamma rays.

Modelling

How do we model the field?
We construct an inner and outer region with a central B_0 value [Marsh et. al. 2017]. This B_0 value is constrained to a realistic value by comparing RM values along both lines of sight.

How do we constrain B_0?
We use X-ray data from Chandra and ROSAT to obtain e- density values and thus RM values along two lines of sight [M87 & M84] and compare them to real values.



Data Collection

What instruments can we use?
We can use data from High Energy Gamma Ray Telescopes such as HESS, MAGIC or Fermi LAT to fit our models to and attempt to verify the presence of Axions or ALPs.

This will be carried out in the next stage of research.

Applying The Model

How do we connect it to Axions?
We simulate random realizations for the field and make calculations for photon-ALP oscillations along the line of propagation for the different m and g values.

Why do we want to use it?
We simulate the propagation for around 1000 realizations across the matrix of m and g values, leading to a total of 12,000 simulations!

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Images:
NASA, Wikimedia, Stock