Axions & Polarisation of Quasars

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Axions

The Strong CP Problem (SCPP)

The CP-violating term normally entering the QCD Lagrangian

$$L_\theta = \theta \frac{g^2}{64\pi^2} \varepsilon^{\alpha\beta\mu\nu} F^c_{\alpha\beta} F_{c\mu\nu},$$

is highly suppressed, as experimentally measurements of the neutron electric dipole moment give $\theta < 10^{-9}$, and we do not have a definite answer why it is so.

One of the favourite solutions to this has been given by Peccei and Quinn in 1977 who postulated a new continuous symmetry

$$U(1)_{P-Q}$$

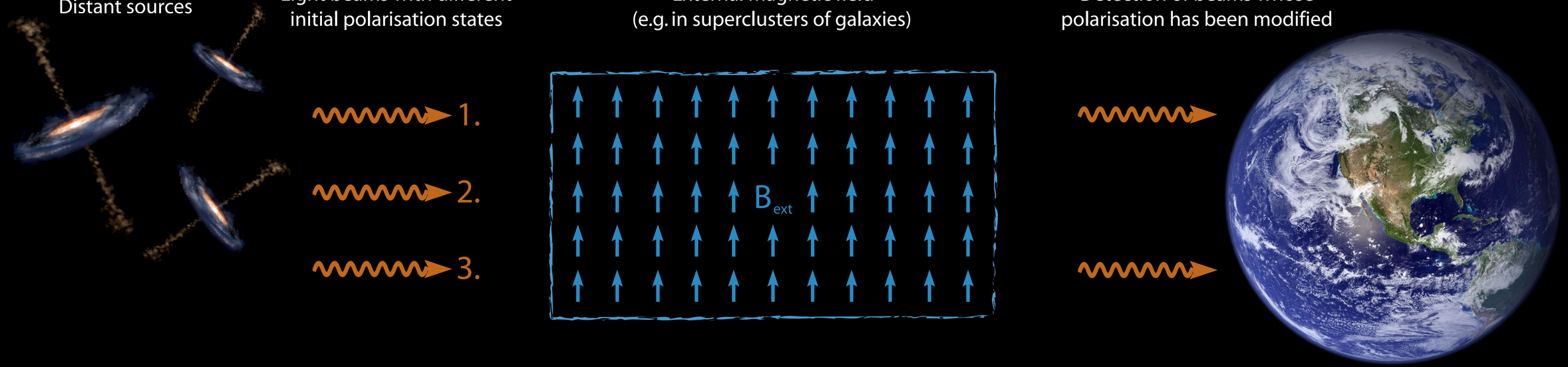
whose spontaneous breaking solved the problem by a dynamic compensation of the θ-term.

Due to this spontaneous symmetry breaking, Weinberg and Wilczek noted in 1978 that a new elementary particle, a pseudo-Goldstone boson, should appear: the axion.

Axion ID
- pseudoscalar particle
- couples with light
- very small mass
- very weakly interacting
- almost stable

to be observed

Polarisation



Axion-photon mixing in external magnetic fields creates/modifies polarisation

Only the electric field component parallel to the external magnetic field is affected.

Light beam n° 1.

Initially polarised perpendicular to B_{ext}

At the end of the magnetic field region:

Unaffected

Light beam n° 2.

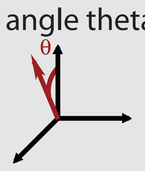
Initially polarised parallel to B_{ext}

At the end of the magnetic field region:

Dimmed

Light beam n° 3.

Initially making an angle theta with respect to B_{ext}



At the end of the magnetic field region:

- Rotation of the polarisation plane
- Phase-shift between the polarisations perpendicular and parallel to B

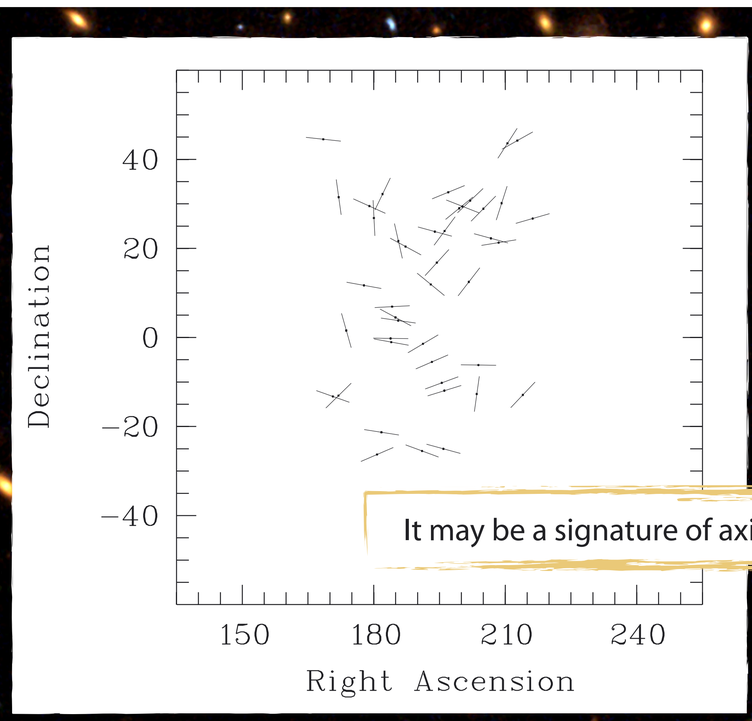
Dichroism (selective absorption)

Birefringence (different velocities)

Quasars

In some regions of the sky, there are very large scale alignments of polarisation vectors for visible light coming from different quasars.

The probability for coincidental alignments is around 0.01%.



Map of polarisation vectors of quasars in one particular region. All redshifts are between 0 and 1 and the coordinates are in degrees. The mean direction is $\theta = 79°$.

It may be a signature of axion-like particles !

Also, the preferred orientation of polarisation vectors is different at different redshifts for similar lines of sight.

non-local effect