Lower Mass Limit for the Axion

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The axion is a (pseudoscalar) spin-0 boson predicted by Wilczek [1] and Weinberg [2] as a solution to the so-called strong-CP problem identified by Peccei and Quinn [3].

Since axions are bosons they can in principle form a Bose-Einstein condensate with characteristic radius L. There is recent evidence [4] that the formation of such a condensate has a coherence length $l \le L$ whose growth is related by

$$\frac{d\,l^2}{t} = \frac{3.4\hbar}{m}\,, \tag{1}$$

where m is the mass of the boson. Supposing that dl/dt is limited by the speed of light, c, we infer that

$$m \ge \frac{1.7\hbar}{cl} \approx \frac{6 \times 10^{-11} m_e}{l}\,, \tag{2}$$

for l in meters, where $m_e \approx 10^{-30}$ kg is the mass of the electron. For $l \approx L = 1$ m, as might be achieved in an experiment [5] where axions are confined in a long optical fiber coiled into a circle of 1-m diameter inside a strong magnetic field, eq. (2) implies that $m \gtrsim 6 \times 10^{-11} m_e$ and $m/c^2 \gtrsim 3 \times 10^{-5}$ eV which is somewhat above the lower end of the stated range of sensitivity of the experiment. For a fiber coiled into a circle of 10-cm diameter the mass limit would be 10 times higher.

References

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