Quantum effects in axion dark matter

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Axion-like particles (ALPs) are promising dark matter candidates. A classical field description is typically employed, motivated by large phase space occupation numbers. Here we show that such a description is accompanied by a quantum effect: squeezing due to gravitational self-interactions. For a typical QCD axion today, the onset of squeezing is reached on microsecond-scales and grows over millennia. Thus within the usual models based on the classical Schrödinger-Poisson equation, a type of Gross-Pitaevskii equation, any viable ALP is nonclassical. We also show that squeezing may be relevant on scales of galactic solitonic cores. Conversely, our results highlight the incompleteness and limitations of the typically employed classical single field description of ALPs.