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New Theoretical and Experimental Perspectives on Axions

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It is sometimes claimed that the Strong CP problem can be solved by invoking mechanisms that impose CP as a symmetry of the theory. I will argue that these solutions do not work. The strong CP problem arises from the fact that the CP invariant QCD Hamiltonian possesses states that violate CP. It is thus a problem of state selection - why are we in a state of QCD which respects CP even though there are many states that violate CP? Imposition of CP as a symmetry is a restriction on the Hamiltonian - but it cannot be used to restrict the states of the theory. Since the strong CP problem is a question of state selection as opposed to the symmetries of the Hamiltonian, it can only be solved through dynamical mechanisms that can relax any initial non-CP preserving state to a CP preserving state. The axion is the only known dynamical way to achieve this, considerably elevating the theoretical motivations for its existence. After presenting this argument, I will discuss a proposal to find axions with a mass around 100 GHz using nonlinear optical materials.

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