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Axionlike particles search using diatomic molecules

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Molecules containing heavy element atoms can be utilized to explore “new” physics beyond the Standard Model through precision experiments designed to detect violations of spatial parity (P) and time reversal (T) symmetries in fundamental interactions. One of the most commonly discussed sources of T and P violation in molecules is the electron electric dipole moment (eEDM) [1]. Although a non-zero eEDM has yet to be observed, limits on its value have been established. The most stringent constraint to date was obtained by the JILA group in their experiment with the hafnium monofluoride (HfF+) molecular cation [2]. Additionally, an upcoming experiment with barium monofluoride (BaF) is anticipated to yield a similarly close independent constraint [3].

However, the violation of time reversal (T) and parity (P) symmetries in fundamental interactions within molecules can arise not only from the eEDM but also from the exchange of virtual axionlike particles between electrons and between electrons and nuclei. In this study, we examined this effect in the hafnium monofluoride (HfF+) molecular cation and the barium monofluoride (BaF) molecule. For the electron-nucleus interaction, our calculations accounted for the finite size of the nucleus. By analyzing the molecular parameters related to these interactions, we established constraints on the products of interaction coupling constants that align with the current sensitivity of experiments involving HfF+ [2] and the anticipated sensitivity of future experiments with BaF [3]. The results were published in references [4] and [5]. Additionally, we will discuss new findings on parity violation effects that were not included in those publications.

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