A Stern-Gerlach separator of chiral enantiomers
based on the Casimir-Polder potential

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Many molecules are chiral which can exist in left- and right-handed forms (i.e., non-superimposable mirror images, Figure 1). These two forms of a chiral molecule are known as enantiomers. Distinguishing two types of enantiomers is of great practical importance. For example, in designing pharmaceuticals, it is necessary to choose the right enantiomer to obtain the desired effects since the other enantiomer is less active, inactive, or can even have adverse side effects, including high toxicity. However, in the conventional methods such as chromatography, the selection of columns is still remains a matter of trial and error, and it is difficult to find materials that show both high efficiency and high enantio-selectivity.

Therefore we propose a more universal method to separate enantiomers which only utilizes the parity-violating Casimir-Polder force between chiral metamaterials and chiral molecules induced by photo excitations and emissions. The Casimir-Polder force is effective quantum electrodynamical force between neutral, unpolarised molecules and macroscopic bodies which arises from the interaction of the objects’ charge and current densities with the quantum vacuum fluctuation of the electromagnetic field. Although the force is typically attractive, it turned out that the sign of the force between a chiral molecule and a chiral metamaterial depends on chirality of the molecule and the material. Especially, the force takes the opposite signs for enantiomers. By using this parity-violation of the Casimir-Polder force, we separate enantiomers as follows:

We let a molecular beam composed of chiral molecules pass through in a planar cavity consisting of two chiral mirrors (Figure 2). Then enantiomers of opposite handedness are deflected differently due to the Casimir-Polder force. Consequently, we found that enantiomers of opposite handedness can be separated around one millimeter after one second due to the parity-violation of the Casimir-Polder force (Figure 3). Our analysis shows that our setup can provide an alternative experimental tool for enantiomer separation, as well as shed light on the fundamental properties of the Casimir-Polder force.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure1.png}
\caption{Enantiomers}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure2.png}
\caption{A Stern-Gerlach separator of chiral enantiomers.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure3.png}
\caption{Trajectories of chiral enantiomers in the cavity.}
\end{figure}

Details can be found in arXiv:1808.08642 or in our poster!