# The Dipolar Interaction in a 3D Cavity

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The dipolar interaction between atoms inside a cavity takes an essential effect for their collective behaviors. In literature, there are some different approaches to describe these interactions, which are not fully consistent with each other. With the help the Maxwell equation and the corresponding Green function, by properly considering the propagation dynamics of the dipole field, we obtain a precise description for the magnetic dipolar interaction between two quantum dipoles for general cavity boundary conditions. This result unifies all the interaction terms between permanent dipoles, resonant or non-resonant transition dipoles, and even the counter-rotating interaction terms altogether. In particular, we obtain the dipolar interaction in a rectangular three-dimensional cavity. When the two dipoles are quite near to each other and far from the cavity boundary, their interaction simply returns the free-space result; when the distance between the two dipoles is comparable to their distance to the cavity boundary and the field mode wavelength, the dipole images and near-resonant cavity modes bring in significant corrections. This approach also provides a general way to study the interaction mediated by other kinds of fields.

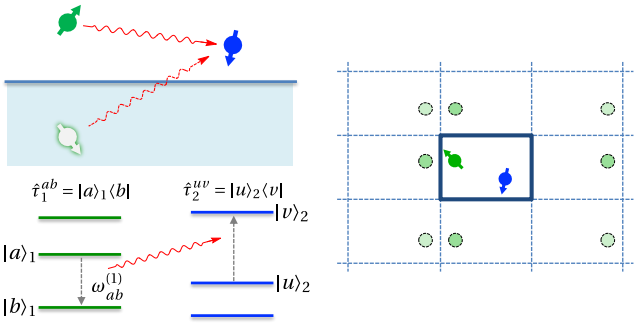


Figure 1: Demonstration for the dipolar interaction induced by the field in a cavity, as well as the dipole images

## References

[1] S-W Li and L-P Yang, Phys. Rev. A **104**, 043709 (2021)