Dynamic Rotative Ferroelectricity of Trojan Electrons on Multiple Parallel Interacting Regular 2-dimensional Lattices

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We have recently discovered that several types or regular two dimensional lattices like square, Honeycomb or face centered Honeycomb lattice are capable to support stable ferroelectric or antiferroelectric ordering of rotating dipole moments by a strong short-range dipole interactions collectively generating local Circularly Polarized electromagnetic fields self-consistently supporting Trojan or anti-Trojan Wave Packets [1].
Several parallel layers of such 2D lattices are considered here where we show that it is possible to obtain the native ferroelectric order of all atoms coherently carrying circulating persistent currents in the Trojan Wave Packet state where the inter-layer distance is sufficiently close and the interactions are sufficiently strong.

We solve the system of the time-dependent Hartree equations within the nearest-neighbors Bethe-Peierls-Weiss approximation. We obtain the following effective Gross-Piaevskii-like equation for any lattice node

$$\left(-\frac{\nabla}{2}^2 - \frac{1}{|\mathbf{r}|} - \sum_{i=1}^{NN}\frac{1}{|\mathbf{r}-\mathbf{w}_i|} + \int \frac{|\phi(\mathbf{r}'-\mathbf{w}_i,t)|^2}{|\mathbf{r}-\mathbf{r}'|}d\mathbf{r}'\right)\phi = i\dot{\phi}$$

where the summation is made over $\mathbf{w}_i$, both the nearest neighbors position within a single lattice as well as nearest neighbors between the parallel lattices surrounding a given Trojan atom. In case of all 2D lattices in which we have previously found various ferroelectric orders with anti-Trojan Wave Packets and anti-ferroeletric orders with Trojan Wave Packets we find the native ferroelectric order when all hydrogen atoms are in the same Trojan Wave Packet state only if the inter-layer distance between the lattices is sufficiently close.

References

1. M. Kalinski, J. H. Eberly, J. A. West, and C. R. Stroud, Jr., "Rutherford atom in quantum theory", Phys. Rev. A **67**, 032503 (2003).