Titel

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I. INTRODUCTION

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II. ONE-DIMENSIONAL CHARGE DENSITY WAVES

Materials in which the electron density $\rho(x)$ is modulated with a wave of wavelength $\lambda = \frac{2\pi}{Q}$ are said to contain a charge density wave. In this paper, we will treat a simple model for a one-dimensional chain of atoms containing such a charge density wave:

$$H = -t\sum_x (c_x^\dagger c_{x+a} + c_x^\dagger c_{x-a}) + \sum_x (\mu + \Delta\cos(Qx+\phi))c_x^\dagger c_x$$

The first term describes hopping between sites, and the second term contains the chemical potential and the charge density wave.

It is important to notice that if $\lambda = na$ with n integer and a the lattice spacing, the charge order is said to be commensurate, i.e. the charge modulation is neatly periodic in n lattice sites. If λ is not of this form, the charge order is called incommensurate.

After imposing periodic boundary conditions, commensurate charge order is the only option, and the total amount of lattice sites N must equal a multiple of λ.

To diagonalize H, we first apply the canonical Fourier transform:

$$c_x = \frac{1}{\sqrt{N}} \sum_{0\leq k\leq \frac{2\pi}{a}} e^{ikx} c_k$$

The hopping term and the chemical potential both give contributions diagonal in k. After writing $\cos(Qx+\phi) = \frac{1}{2}(e^{i(Qx+\phi)} + e^{-i(Qx+\phi)})$, we see that the charge wave in real space gives an off-diagonal contribution k. The resulting Hamiltonian in Fourier space is:

$$H = \sum_{0\leq k\leq \frac{2\pi}{a}} (\frac{1}{2}\varepsilon_k c_k^\dagger c_k + \Delta_\phi c_k^\dagger c_{k+Q} + \text{H.c.})$$

Where $\varepsilon_k = -2t\cos(ka) + \mu$ and $\Delta_\phi = \Delta e^{i\phi}$, i.e. Δ acquires a phase corresponding to the offset of the charge distribution.

A. Figures and Tables

Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation Fig. 1, even at the beginning of a sentence.

TABLE I

AN EXAMPLE OF A TABLE

One	Two
Three	Four

We suggest that you use a text box to insert a graphic (which is ideally a 300 dpi TIFF or EPS file, with all fonts embedded) because, in an document, this method is somewhat more stable than directly inserting a picture.

Fig. 1. Inductance of oscillation winding on amorphous magnetic core versus DC bias magnetic field

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity Magnetization, or Magnetization, M, not just M. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write Magnetization (A/m) or Magnetization A[m(1)], not just A/m. Do not label axes with a ratio of quantities and units. For example, write Temperature (K), not Temperature/K.

III. CONCLUSIONS

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

References

[1] Felix Flicker and Jasper van Wezel. Quasiperiodicity and 2d topology in 1d charge-ordered materials. *EPL (Europhysics Letters)*, 111(3):37008, 2015.