Assumptions:

- Tight-binding approximation,
  i.e. continuous space is discretized: $\psi(\mathbf{r}) \to \psi_i$

- Random phase approximation (RPA),
  i.e. 1st order perturbation theory:

Total potential

External perturbation

$$\begin{cases} V = \varepsilon^{-1} \cdot V_{\text{ext}} \\ \varepsilon = 1 - V_{\text{C}} \cdot \chi \end{cases}$$

Dielectric function

Coulomb interaction

Polarizability function

What we can do:

Complete real-space description!

$\boxed{\text{magic}}$: $(\mathcal{H}\ ,\ V_{\text{C}}) \mapsto (\chi(\omega)\ ,\ \varepsilon(\omega))$

for up to $\mathcal{O}(10000)$ sites

(for any Hamiltonian, frequency, temperature, chemical potential, etc.)

Already done:

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Plasmon confinement in fractal quantum systems

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Recent progress in the fabrication of materials has made it possible to create arbitrary nonperiodic two-dimensional structures in the quantum plasmon regime. This paves the way for exploring the quantum plasmonic properties of electron gases in complex geometries. In this work we study systems with a fractal dimension. We calculate the full dielectric functions of two prototypical fractals with different ramification numbers, namely the Sierpinski carpet and gasket. We show that the Sierpinski carpet has a dispersion comparable to a square lattice, but the Sierpinski gasket features highly localized plasmon modes with a flat dispersion. This strong plasmon confinement in finitely ramified fractals can provide a novel setting for manipulating light at the quantum level.

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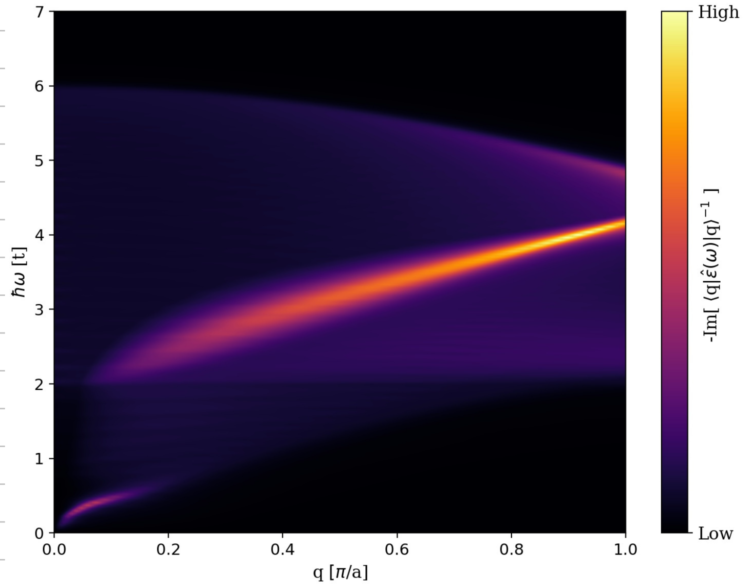
Work in progress:

(by Samber Bastiaansen)



- EELS (Electron Energy Loss Spectroscopy) spectrum;
- Plasmon dispersion;
- Real-space plasmon eigenmodes;