Superconductivity and out of equilibrium systems

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PhD under direction of Karyn Le Hur[1] & Eric Akkermans[2]

Outline

1. Out of equilibrium physics and mesoscopic Casimir forces

2. Out of equilibrium superconductivity

Fluctuation induced forces (Casimir forces)

Fluctuation induced forces: fluctuating medium + confinement
$\Rightarrow$ fluctuation induced forces

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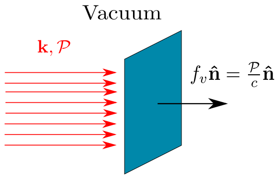

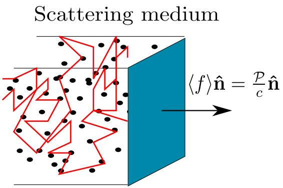

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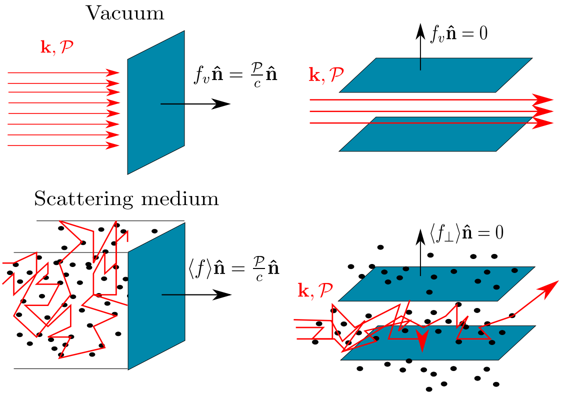

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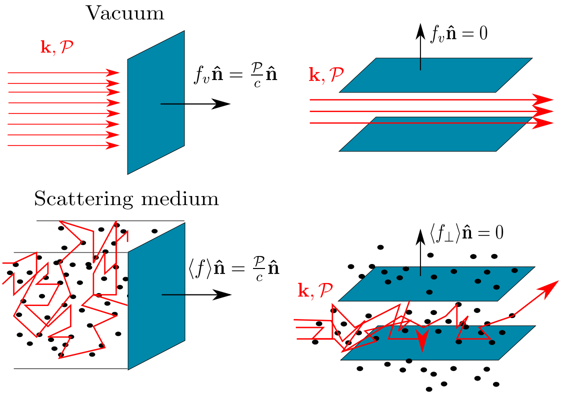
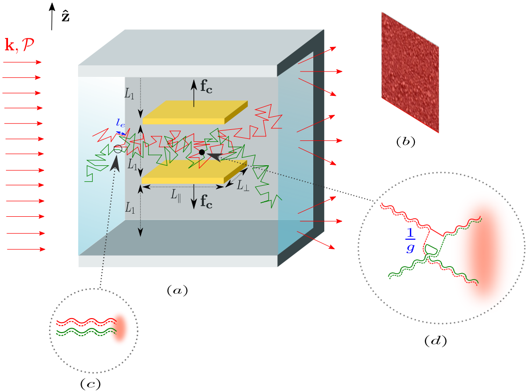


- $\langle f_\perp \rangle = 0$ on average over disorder, but $\delta f_\perp = f_\perp - \langle f_\perp \rangle \neq 0$;
- Spatially long-ranged coherent correlations of the light intensity induce perpendicular forces: fluctuation induced forces;
- These forces are well studied for far out of equilibrium systems.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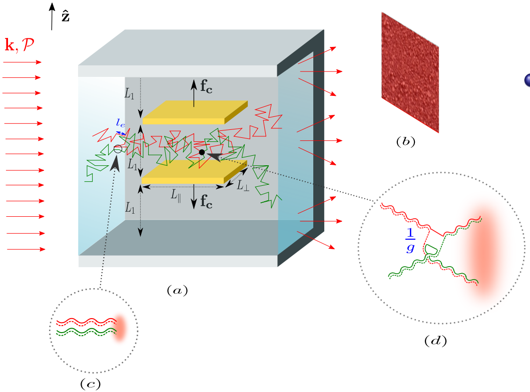

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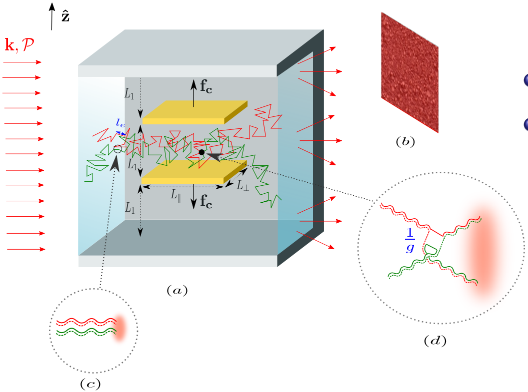

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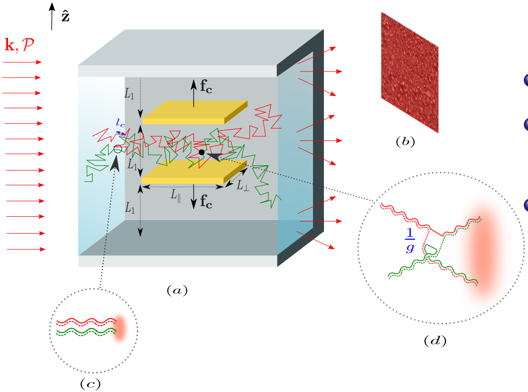
- Langevin:
  $\mathbf{j}(\mathbf{r}) = -D\nabla I(\mathbf{r}) + \boldsymbol{\nu}(\mathbf{r})$



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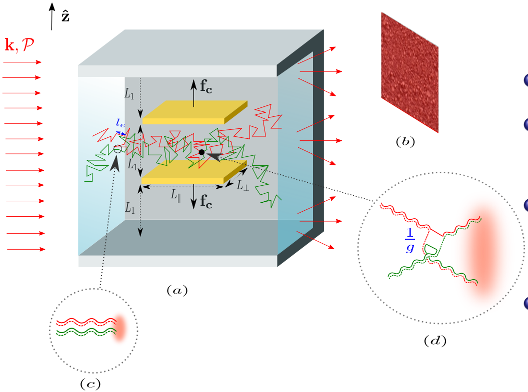

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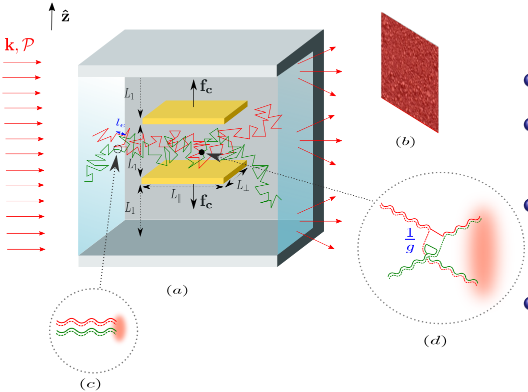

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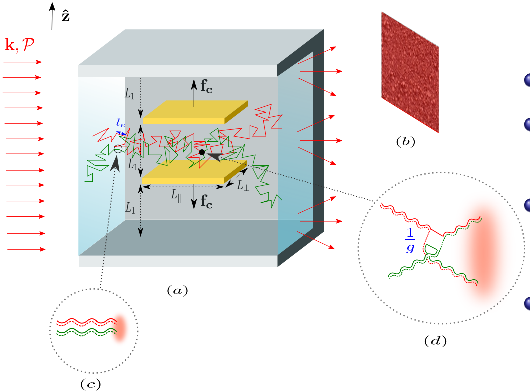
- $\langle f_c^2 \rangle = \frac{1}{c^4} \iint_{S \times S} d\mathbf{r} d\mathbf{r}' [D^2 \partial_z \partial_{z'} \langle \delta I(\mathbf{r}) \delta I(\mathbf{r}') \rangle + \langle \nu_z(\mathbf{r}) \nu_{z'}(\mathbf{r}') \rangle]$



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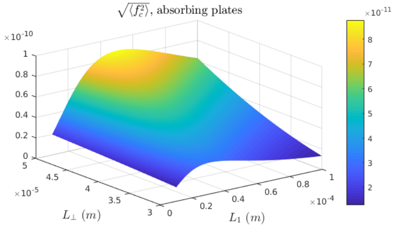
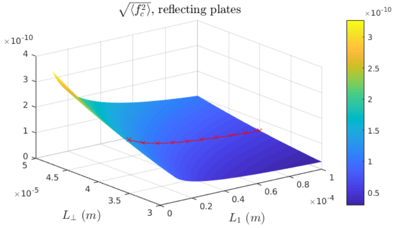
- Universal form: $\langle f_c^2 \rangle = \frac{1}{g_c} \frac{\mathcal{P}^2}{c^2} \xi$
- Dimensionless conductance $g_c = \frac{k^2 le L_1 L_\perp}{3\pi L_\parallel}$

Influence of boundary conditions



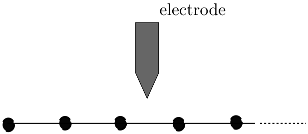


- Absorbing (resp. reflecting) plates single out the intensity (resp. noise) contributions to the Casimir forces
- Order of magnitude of the Casimir forces easily tuned via the conductance and the boundary conditions

→ measurable and significantly more important than in known situations.

Outline

Out of equilibrium topological superconductor



- 1 dimensional spin chain $\equiv$ (topological) $p-$wave superconductor;
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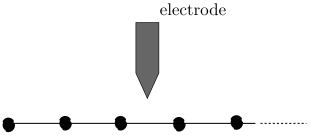

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⇒ Study the dynamics of the Zak phase in the topological superconductor (spin chain) via current measurements.

Perspectives

Perspectives:

- Two papers in progress on fluctuation induced forces;
- Continue the study of out of equilibrium topological superconductor;
- Generalize to the study of the dynamics of spin polarized electric current injected in conventional superconductor.

Thank you!
Questions?