

THEORY AND OPTIMIZATION OF GRAPHENE PHOTOTHERMOELECTRIC DETECTORS

Aron W. Cummings and Aleandro Antidormi

Catalan Institute of Nanoscience and Nanotechnology (ICN2)

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Introduction

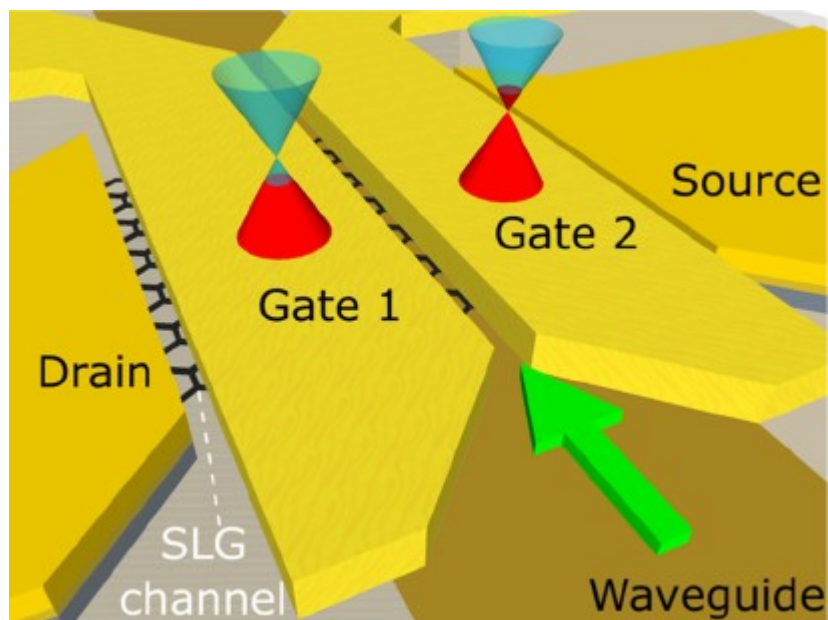
- Graphene photothermoelectric detectors
 - Broadband: THz \rightarrow UV
 - Fast: >67 GHz
- Low power: zero bias

Mišeikis et al., *ACS Nano* **14**, 11190 (2020)



Introduction

- Photothermoelectric effect

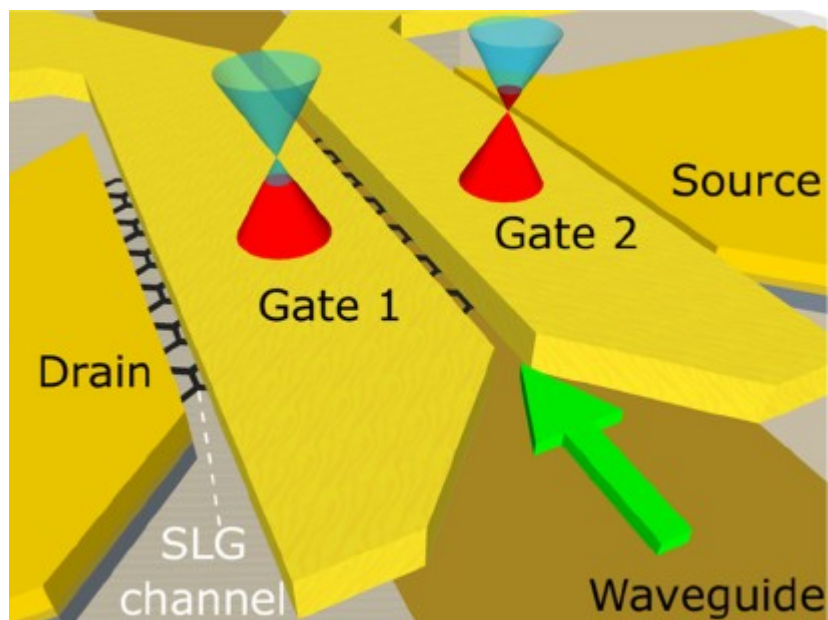


Muench et al., *Nano Lett.* **19**, 7632 (2019)

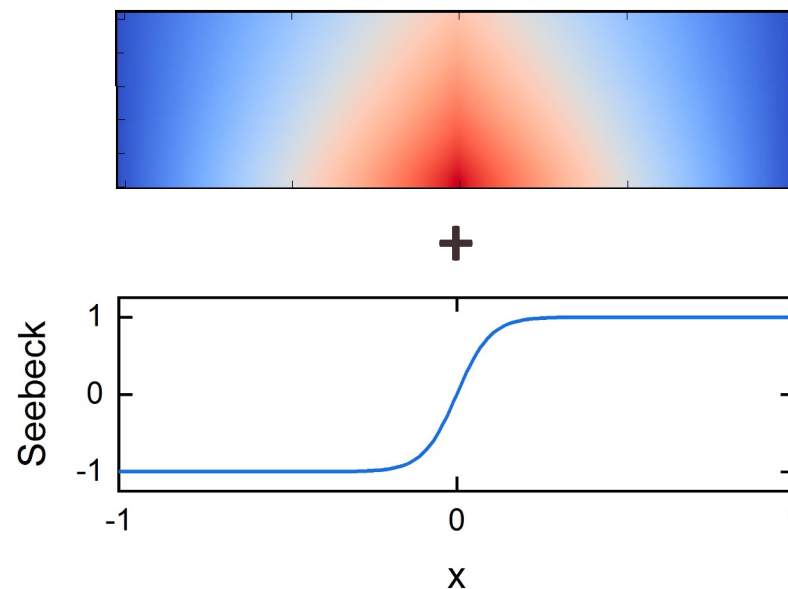


Introduction

■ Photothermoelectric effect

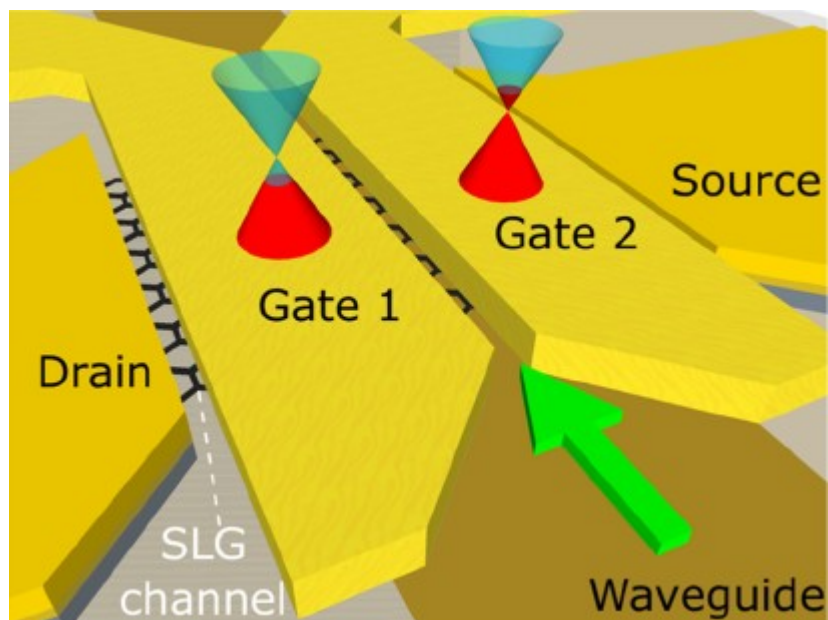


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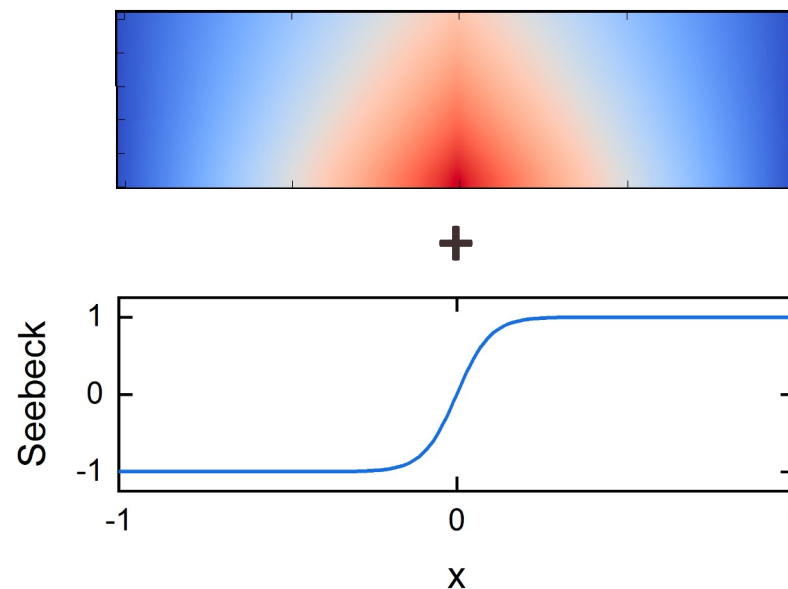


Introduction

■ Photothermoelectric effect



Muench et al., *Nano Lett.* **19**, 7632 (2019)



$$V_{\text{PTE}} = \int S(x) \frac{dT_{el}}{dx} dx$$



Approach

- Solve the heat equation

$$\nabla^2 T_{el} - \frac{T_{el}}{L_c^2} + \frac{P}{\kappa} = 0$$



Approach

- Solve the heat equation

$$\nabla^2 T_{el} - \frac{T_{el}}{L_c^2} + \frac{P}{\kappa} = 0$$

- Derive figures of merit

$$V_{\text{PTE}} = \int S(x) \frac{dT_{el}}{dx} dx$$

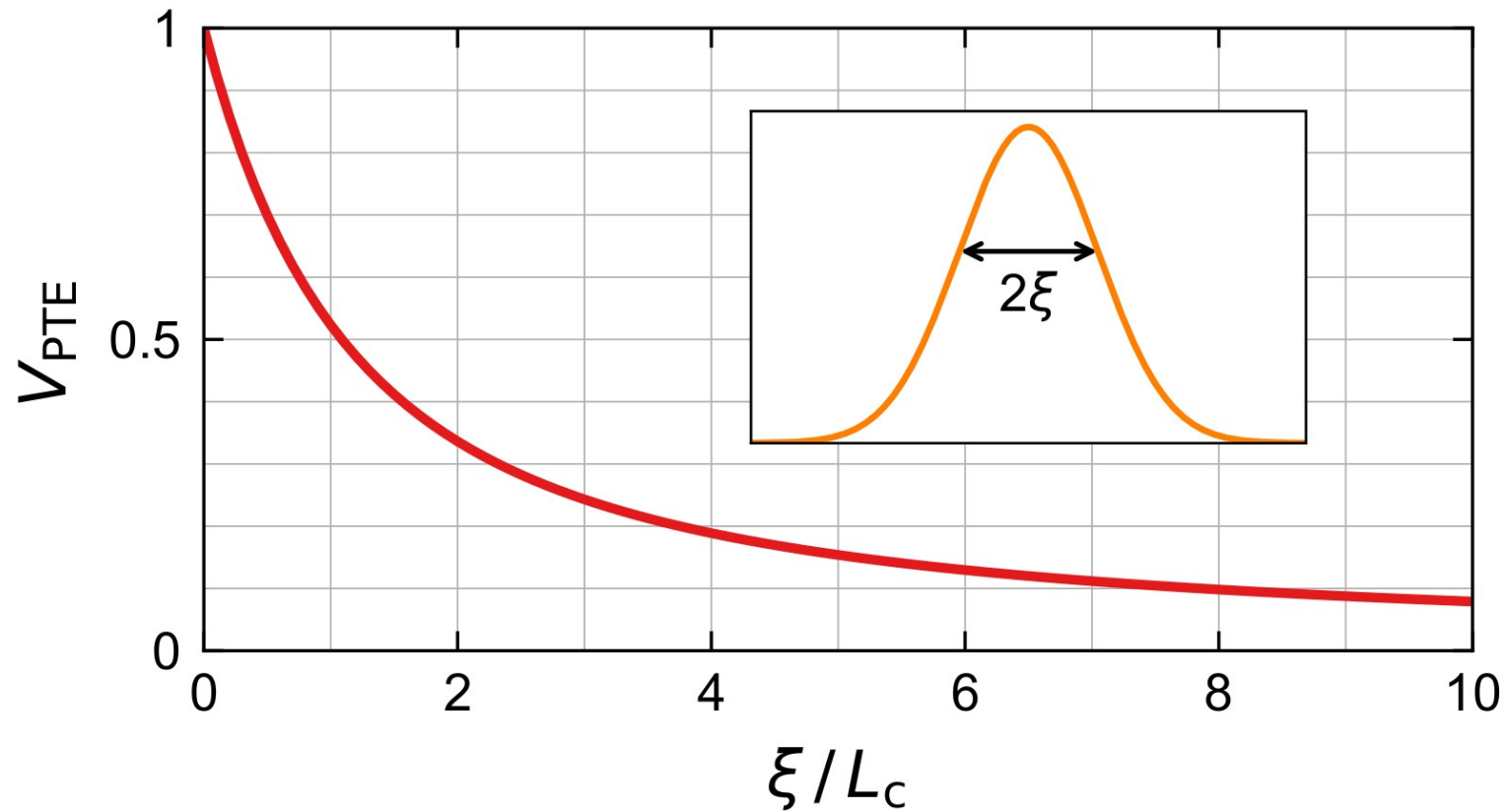
$$I_{\text{PTE}} = V_{\text{PTE}}/R$$

$$\text{NEP} = \sqrt{4kTR}/V_{\text{PTE}}/P_{\text{in}}$$



Results

■ Spot size

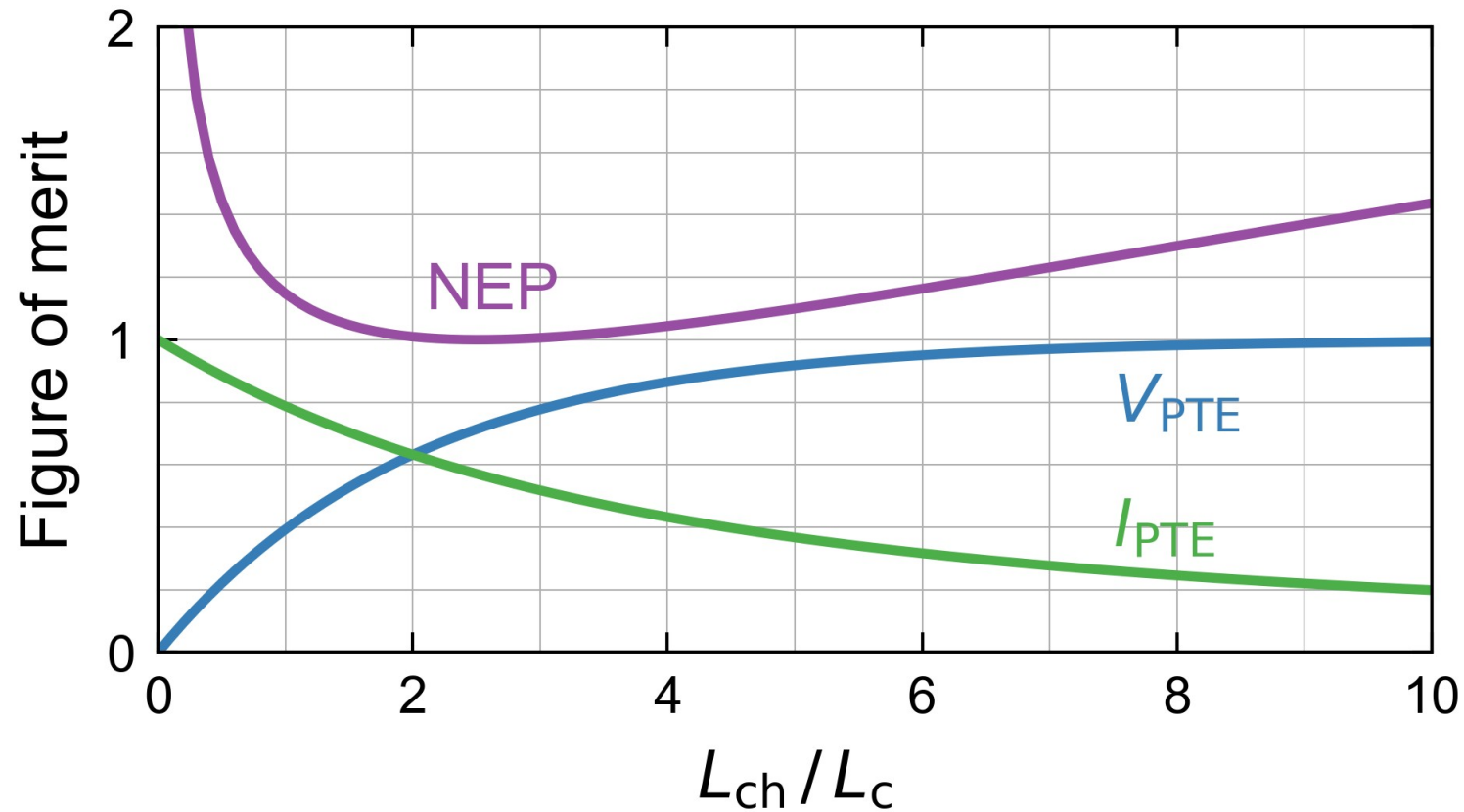


Antidormi and Cummings,
PRApl **15**, 054049 (2021)



Results

■ Channel length

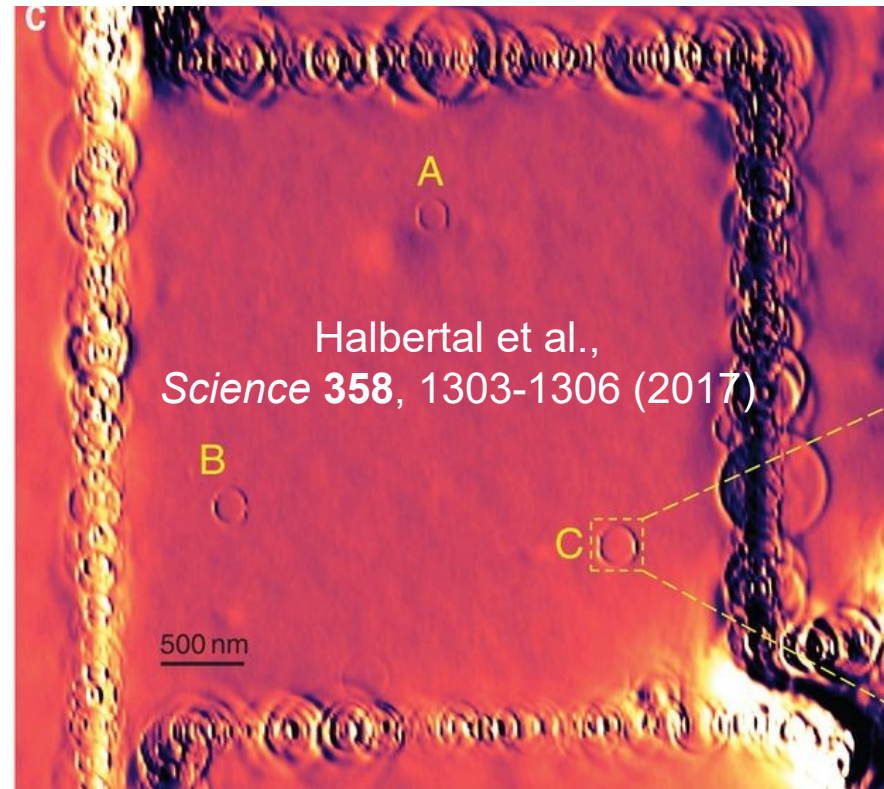


Antidormi and Cummings,
PRAppl **15**, 054049 (2021)



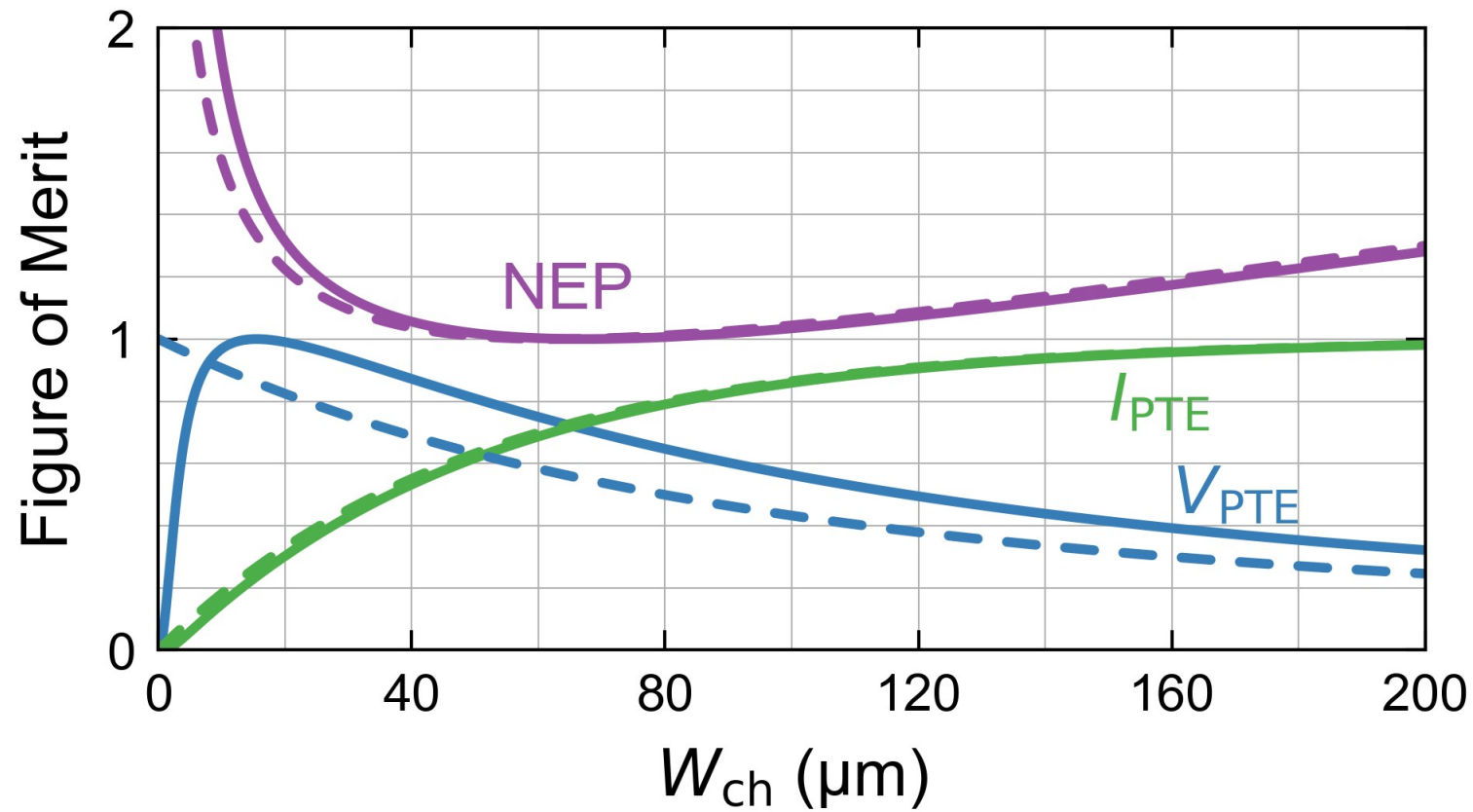
Results

- Channel width



Results

■ Channel width

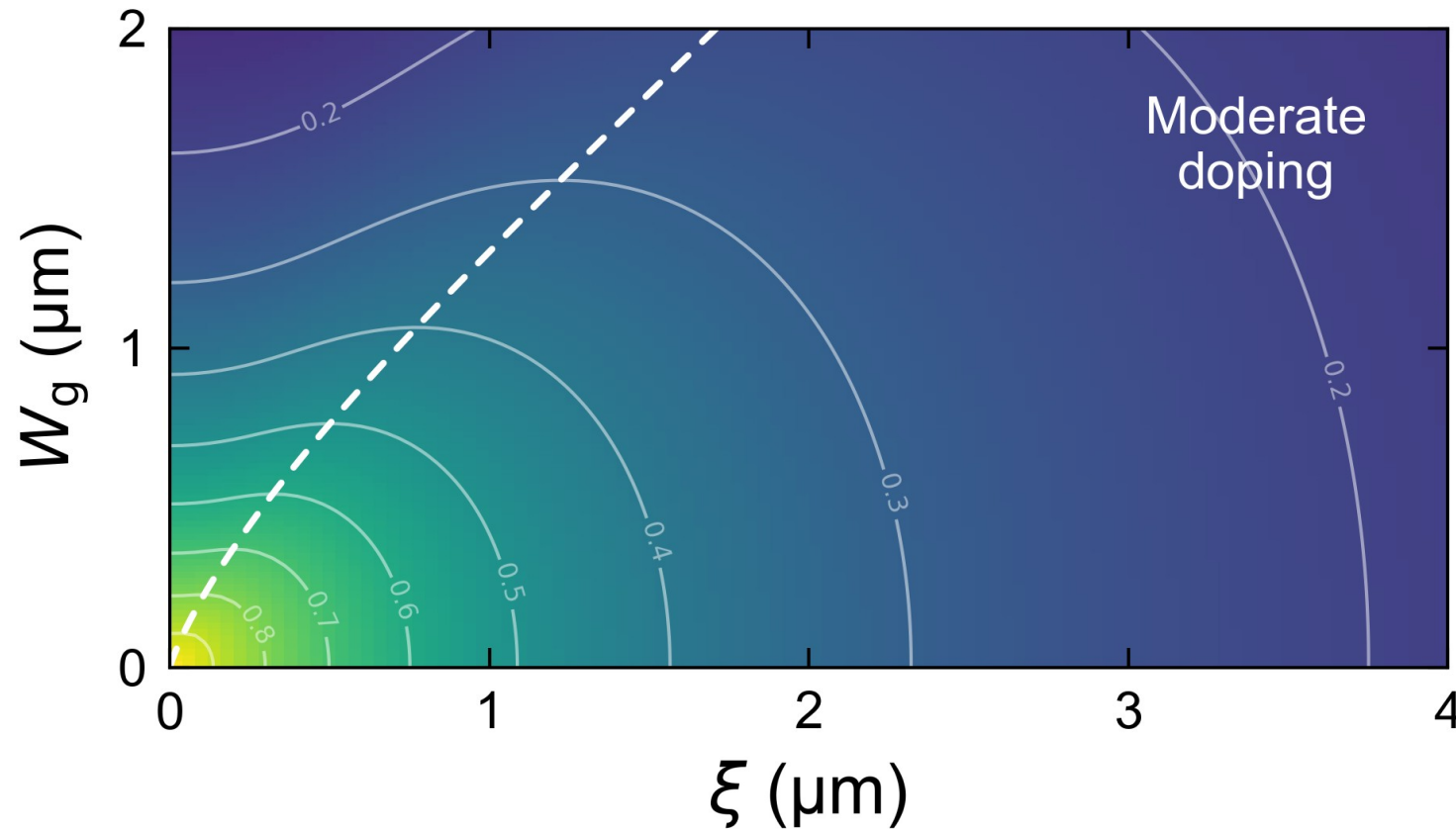


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PRAppl **15**, 054049 (2021)



Results

- Split gate separation / spot size

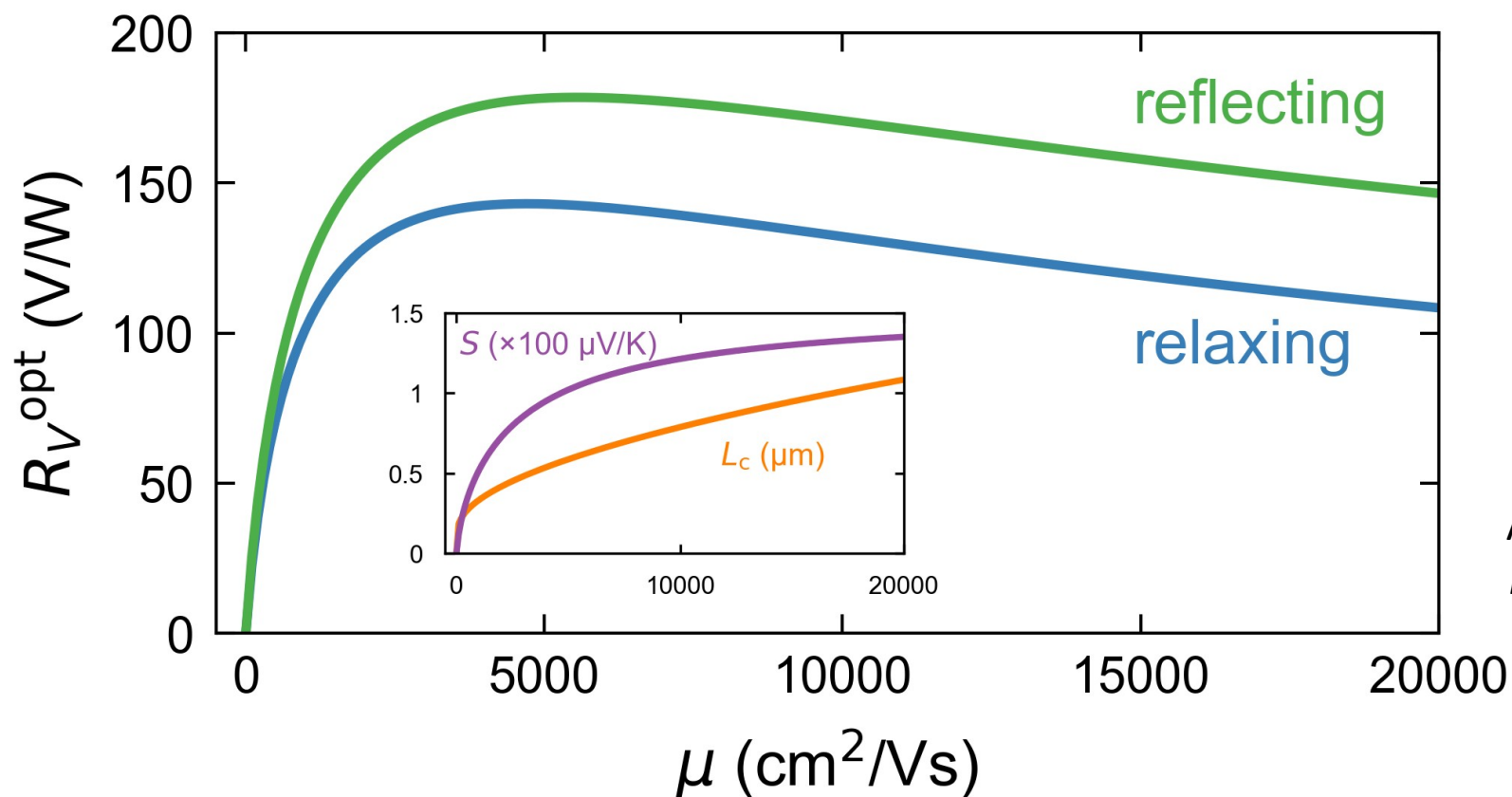


Antidormi and Cummings,
PRAppl **15**, 054049 (2021)



Results

- Graphene quality \rightarrow photovoltage

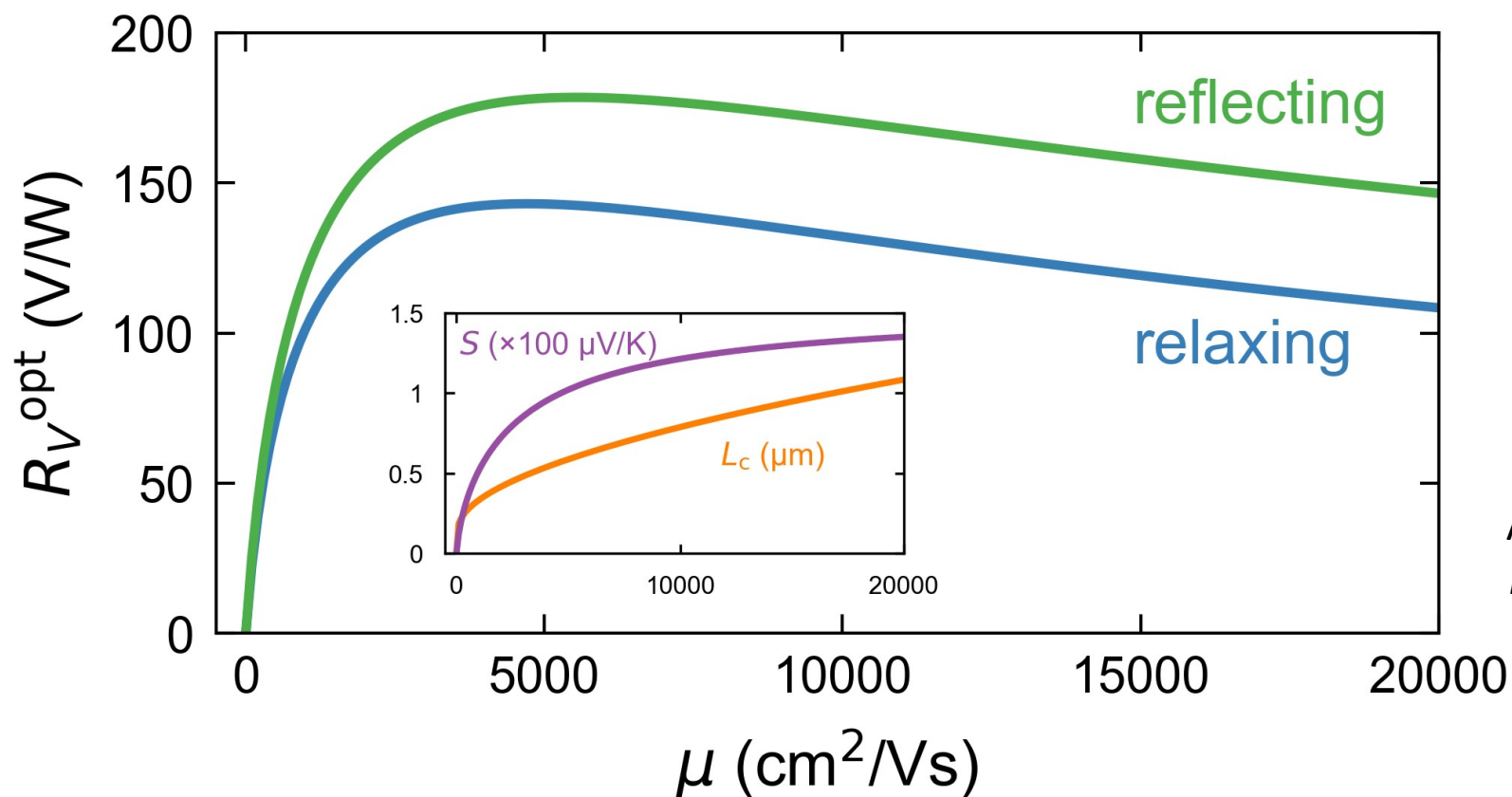


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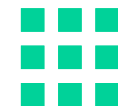
Results

- Graphene quality \rightarrow photovoltage



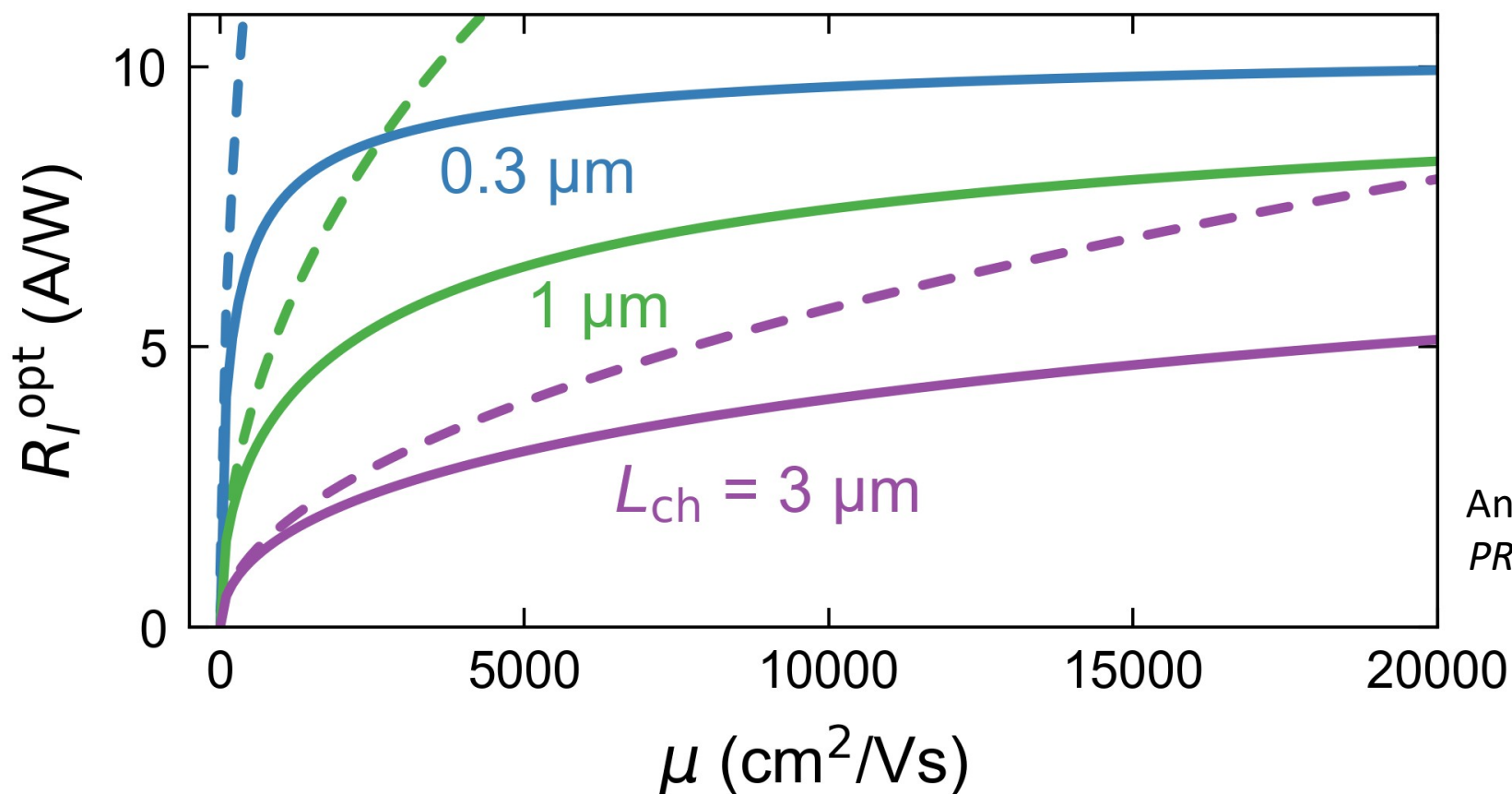
$$V_{\text{PTE}} \propto \frac{S \cdot L_c}{\kappa}$$

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Results

- Graphene quality \rightarrow photocurrent

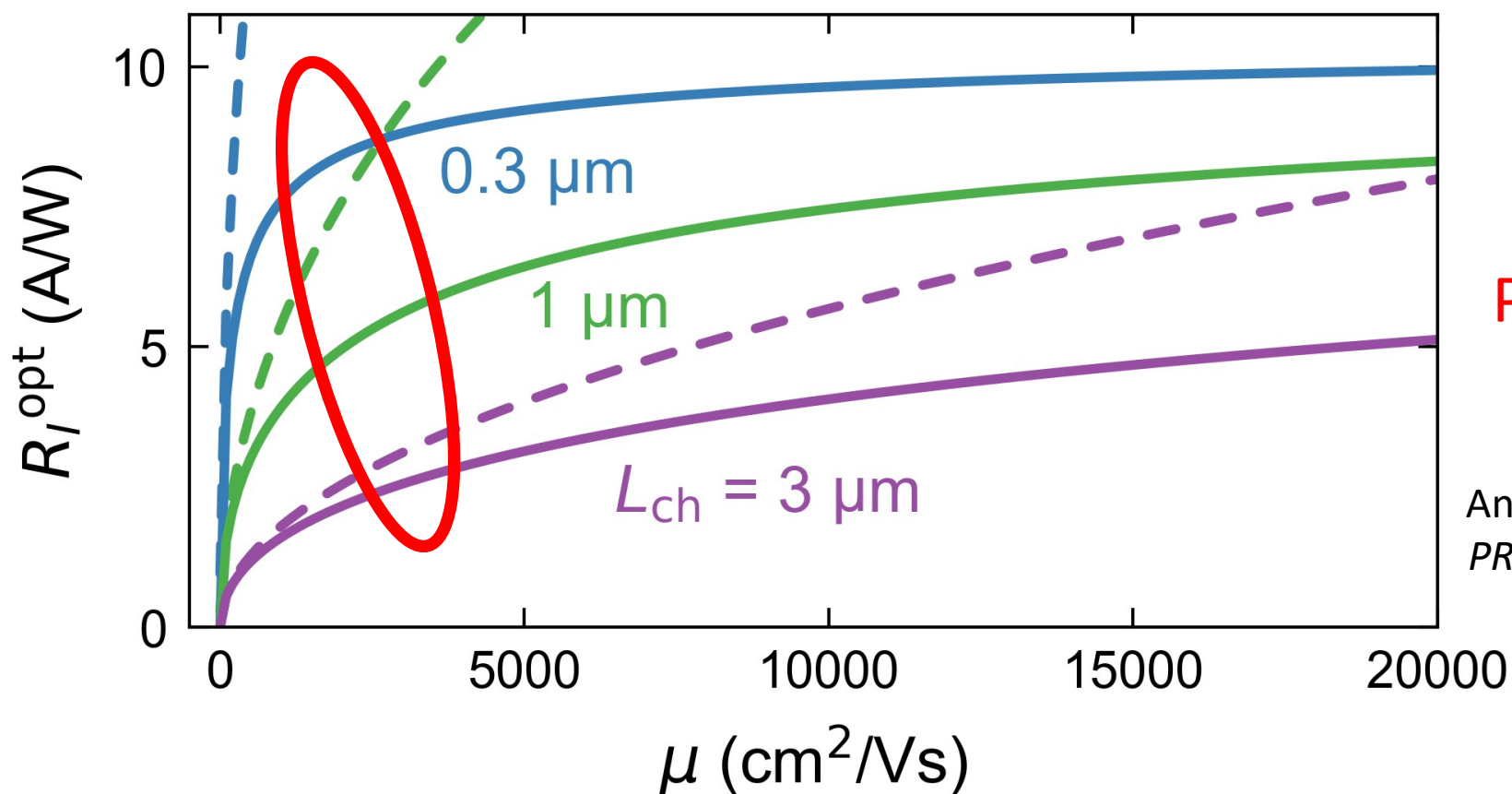


Antidormi and Cummings,
PRAppl **15**, 054049 (2021)



Results

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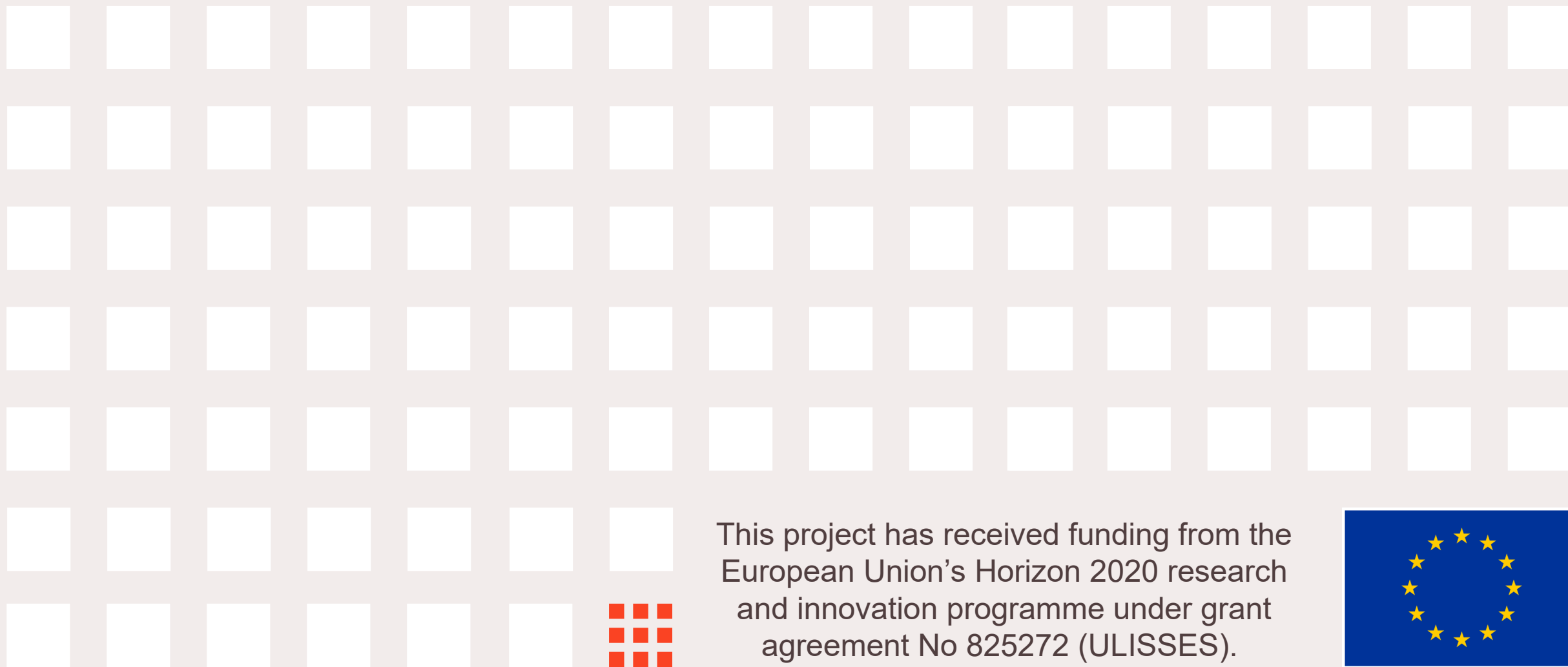


Onset of
Peltier cooling

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Thank you for your attention!



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