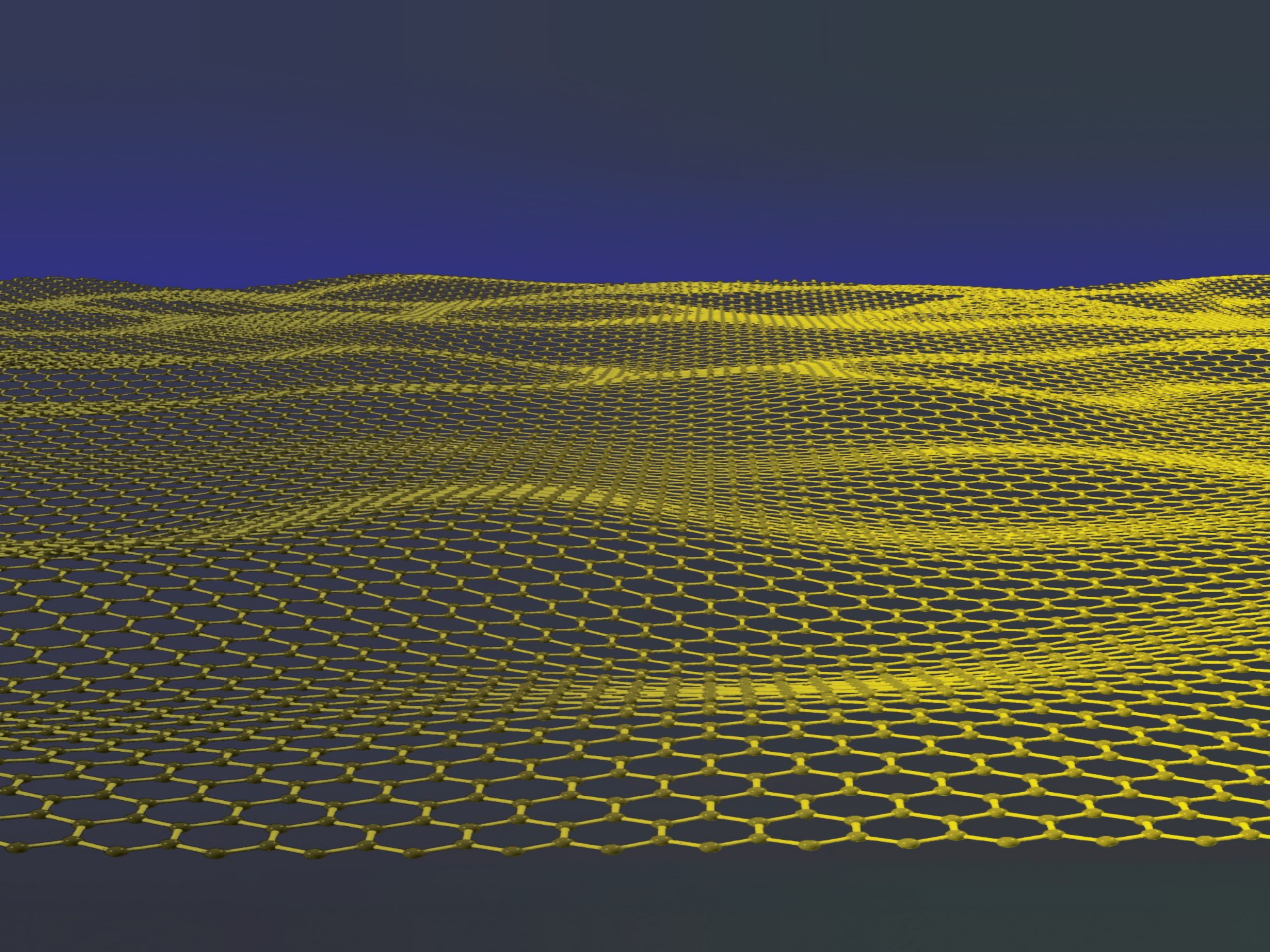
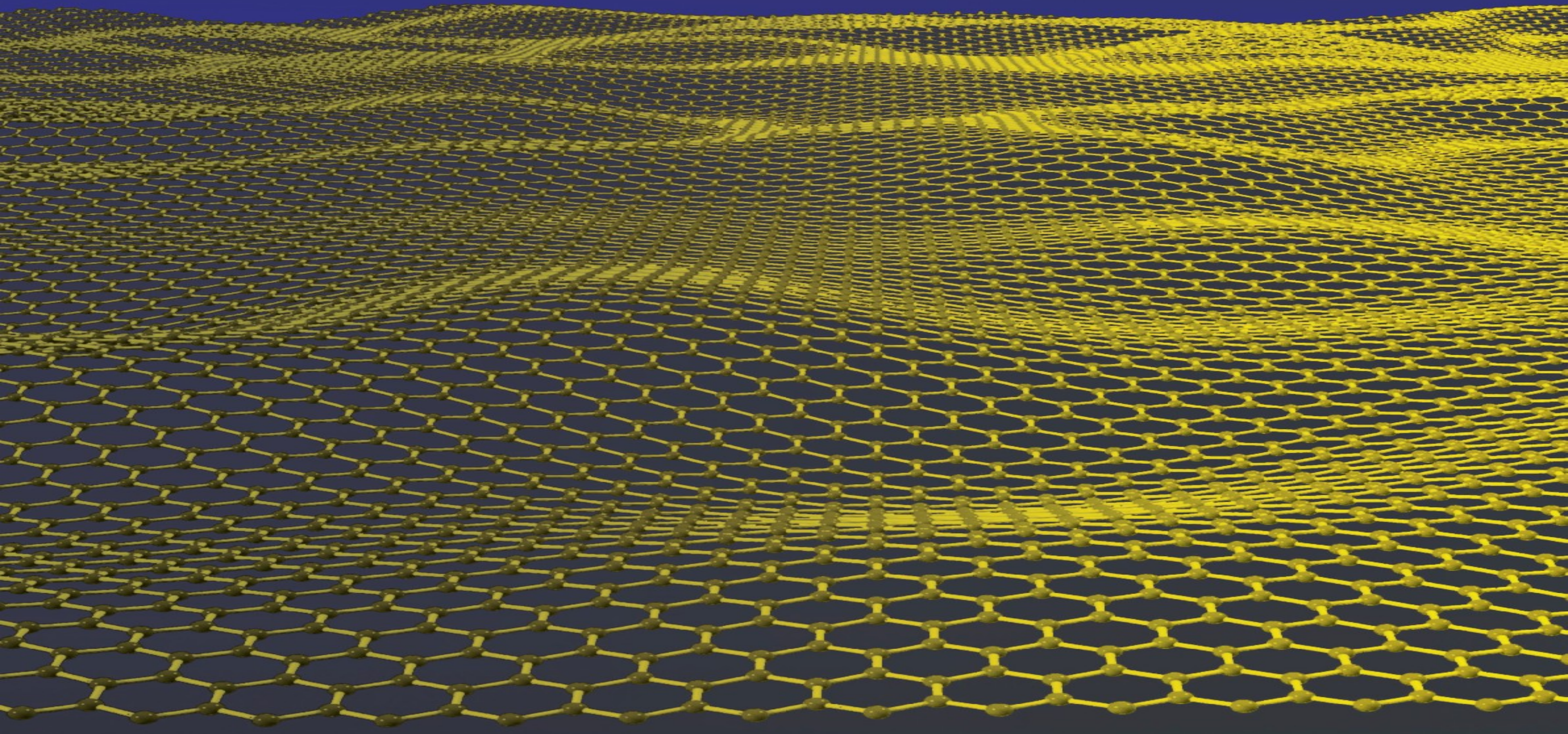


Graphene

and numerical simulations



Nonrelativistic particle

$$E = \frac{mv^2}{2}$$

$$\text{Relativistic} \quad \text{particle}$$

$$E = \sqrt{m^2 c^4 + p^2 c^2}$$

Relativistic particle $E = \sqrt{m^2c^4 + p^2c^2}$

Massless particle $E = cp$

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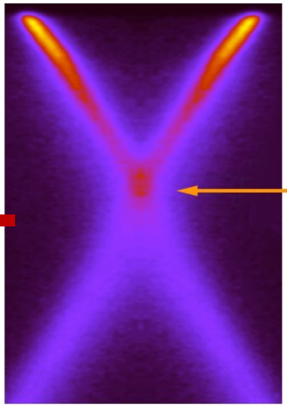
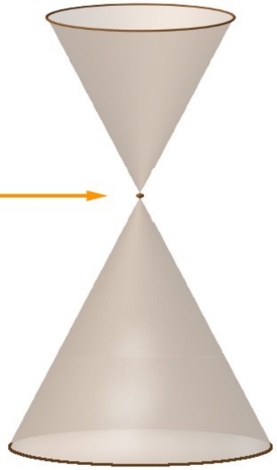




Graphene $E = v_F p; \quad v_F = \frac{c}{300};$

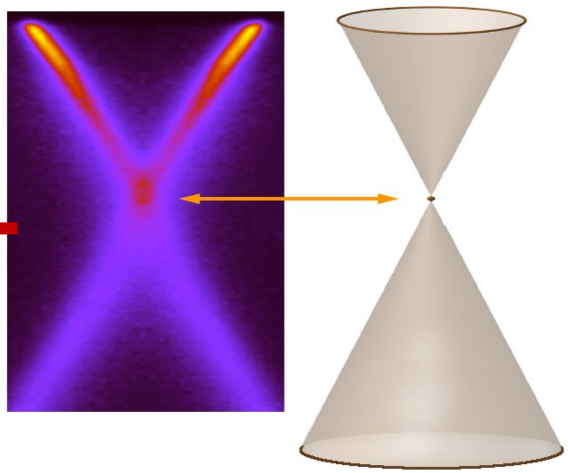
Dirac bispinor!

1

Two dimensional Dirac particles, interacting wia 3D Coulomb

Relativistic particle $E = \sqrt{m^2c^4 + p^2c^2}$

Massless particle $E = cp$



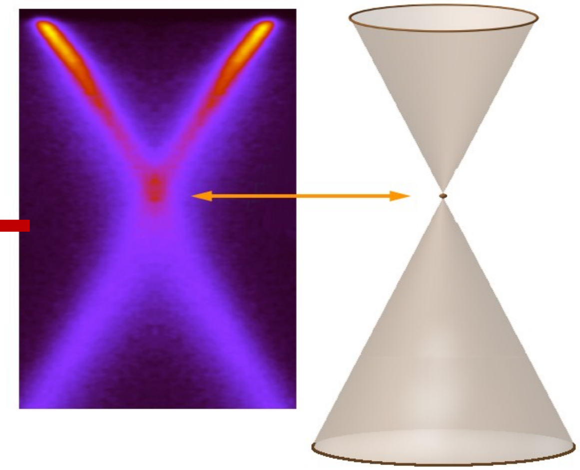
Graphene $E = v_F\, p;\quad v_F = \dfrac{c}{300};$

$\alpha_g = 300\alpha = 2.16 > 1$

$\alpha_g > \alpha_g^{crit} = 1.11 \pm 0.06$ Pure graphene is the insulator!

Relativistic particle $E = \sqrt{m^2c^4 + p^2c^2}$

Massless particle $E = cp$



Graphene $E = v_F p; \quad v_F = \dfrac{c}{300};$

$$\alpha_g = 300\alpha = 2.16 > 1$$

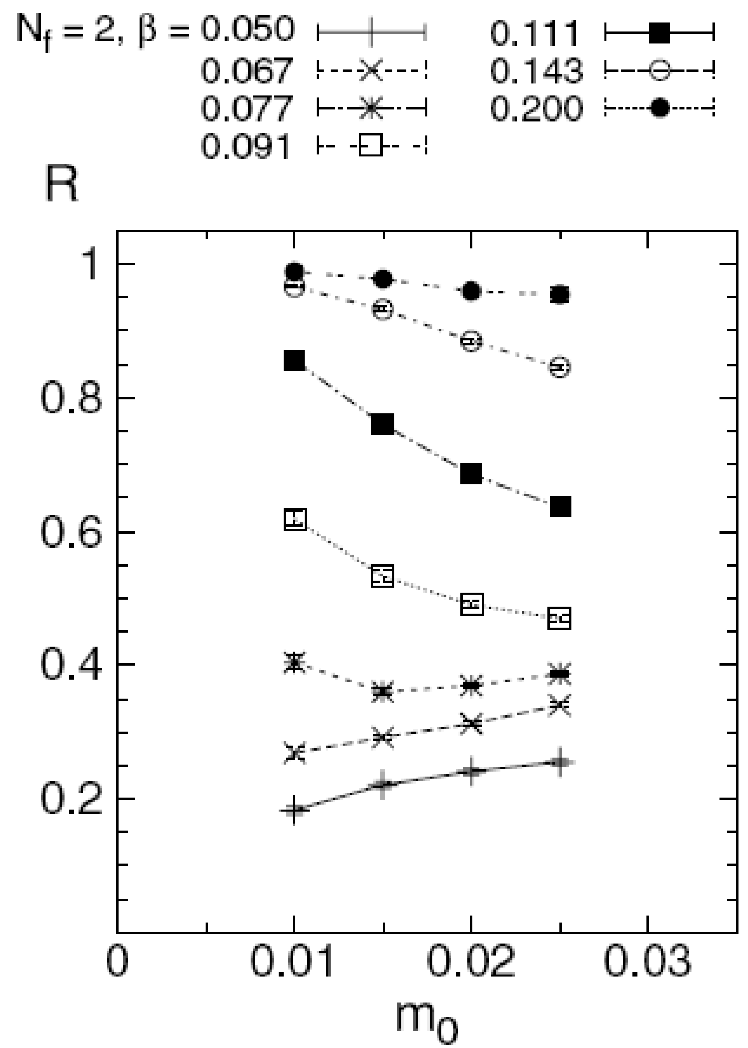
$\alpha_g > \alpha_g^{crit} = 1.11 \pm 0.06$ Pure graphene is the insulator!

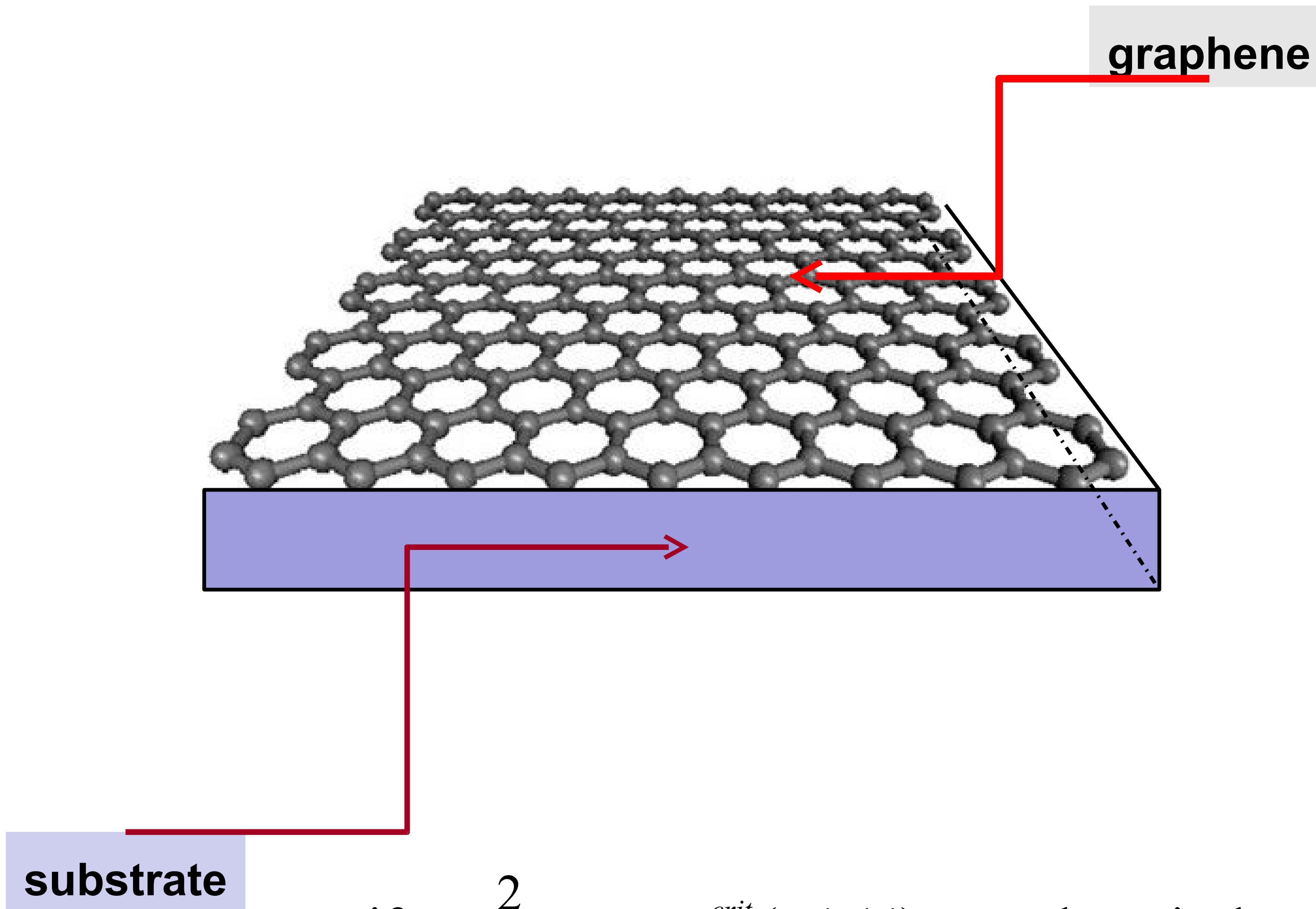
If we put graphene on a substrate we can get conductor: $\alpha_g \to \dfrac{2}{1+\varepsilon}\alpha_g$

Numerical calculation of α_g^{crit} 2

Is graphene in vacuum an insulator?.
Joaquin E. Drut Timo A. Lahde
e-Print: **arXiv:0807.0834 [cond-mat.str-el], PRL (2009)**

Monte Carlo Simulation of the Semimetal-Insulator Phase Transition in Monolayer Graphene.
W. Armour , Simon Hands, Costas Strouthos
Published in **Phys.Rev. B81 (2010) 125105**
e-Print: **arXiv:0910.5646 [cond-mat.str-el]**

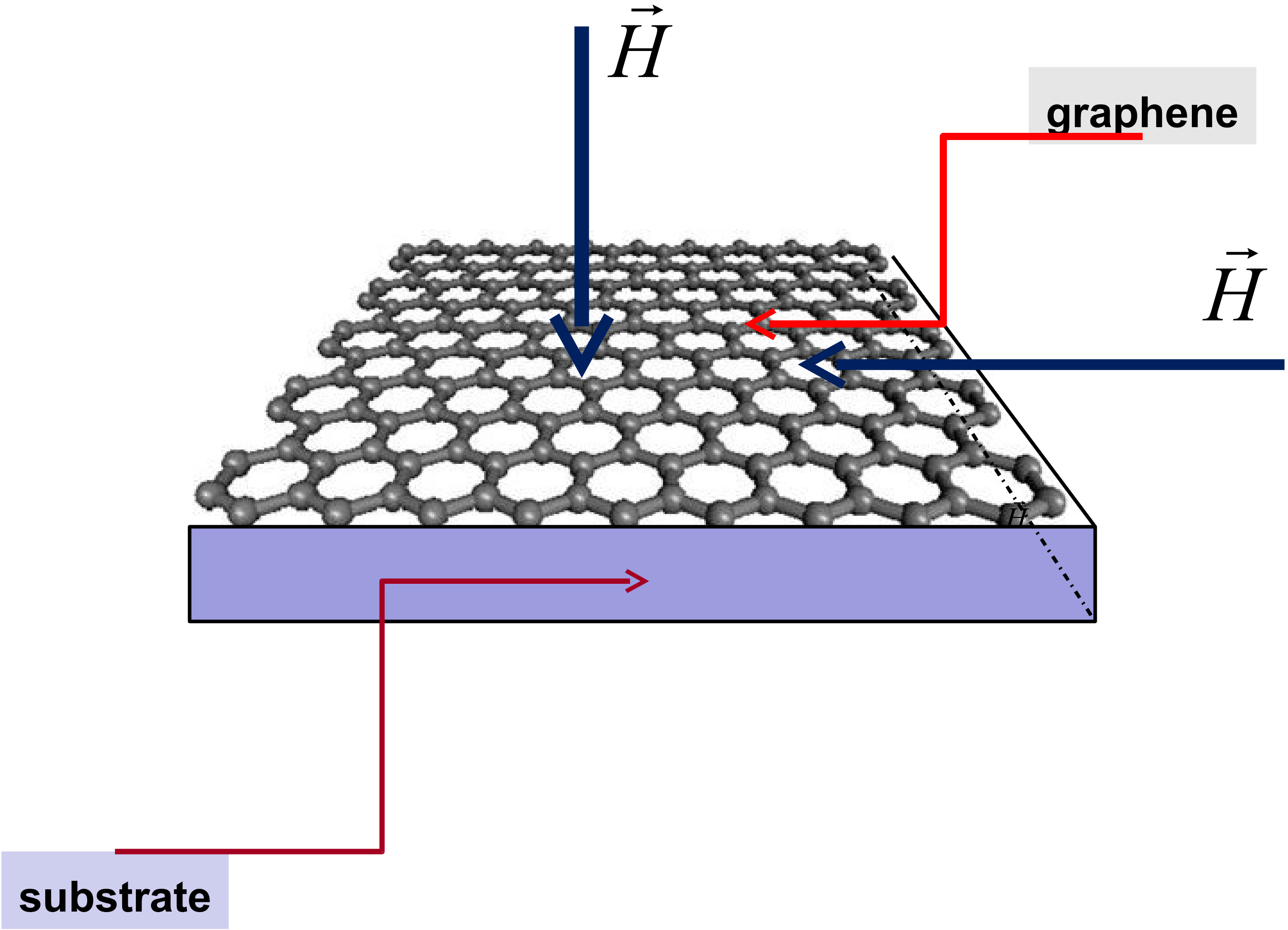




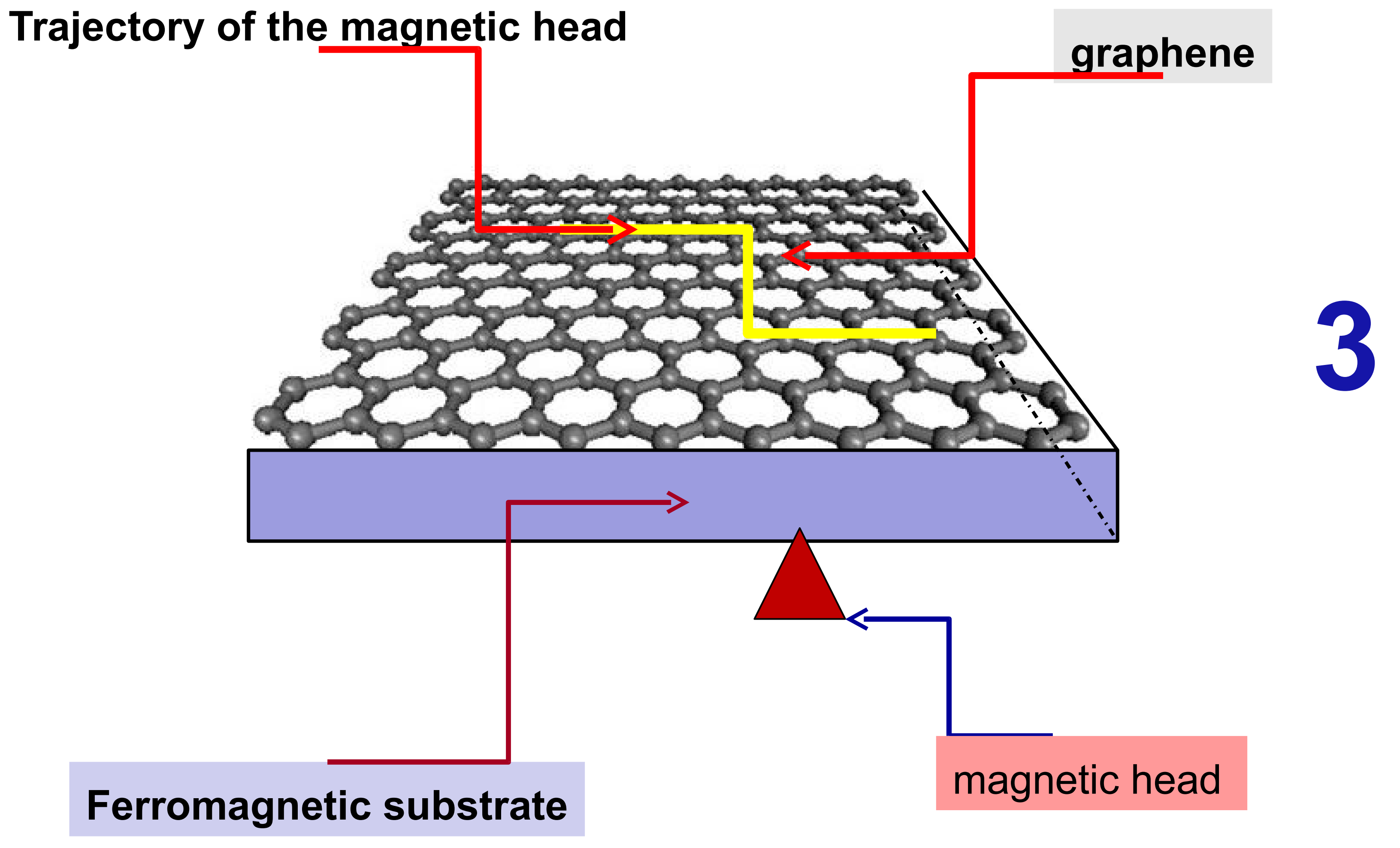
$$\text{if} \quad \frac{2}{1+\varepsilon}\alpha_g > \alpha_g^{crit} (= 1.11) \quad \text{graphene is the conductor}$$

We can numerically simulate conductor – insulator phase transition!

Magnetic Field and Graphene



Graphene changes its properties when an external magnetic field is applied, we can numerically simulate all that



Along the trajectory of the magnetic head graphene becomes the conductor!

We can draw (construct) chips! All that we can simulate on computers

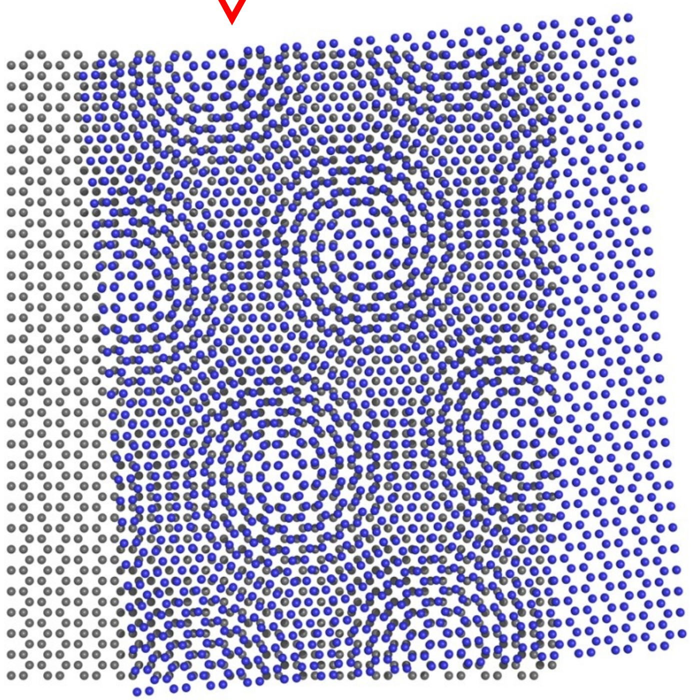
Problems for graphene numerical simulations

- **Magnetic field**
- **Finite temperature**
- **Impurities**
- **2-3-4 layers**
- **Conductivity**
- **Viscosity – Entropy**
- **Optical properties**
- **Critical indices**

Monte Carlo simulation of monolayer graphene at non-zero temperature

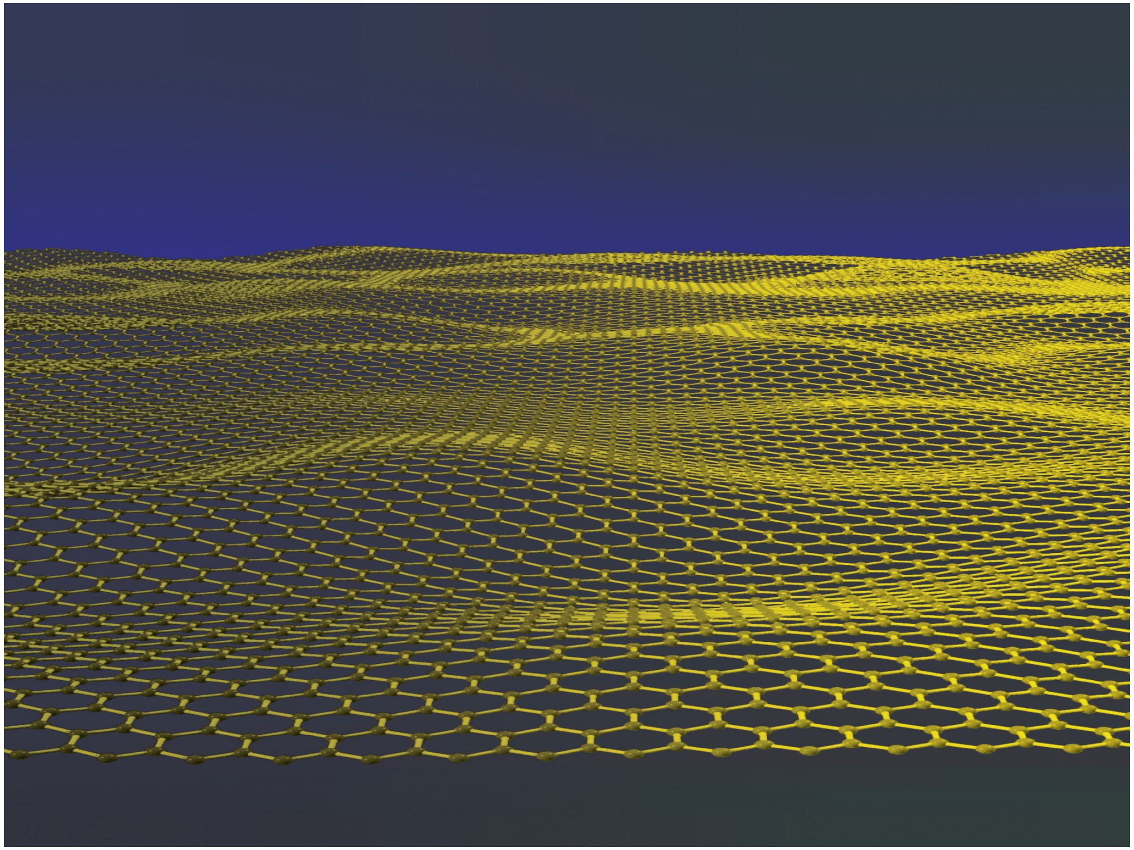
Wesley Armour[a,b], Simon Hands[c], and Costas Strouthos[d]

arXiv:1105.1043v1 [cond-mat.str-el] 5 May 2011



4

Curvature of the graphene leads to two dimensional gravity for fermions
Volovik



5

Graphene simulations

High Temperature Superconductor

simulations