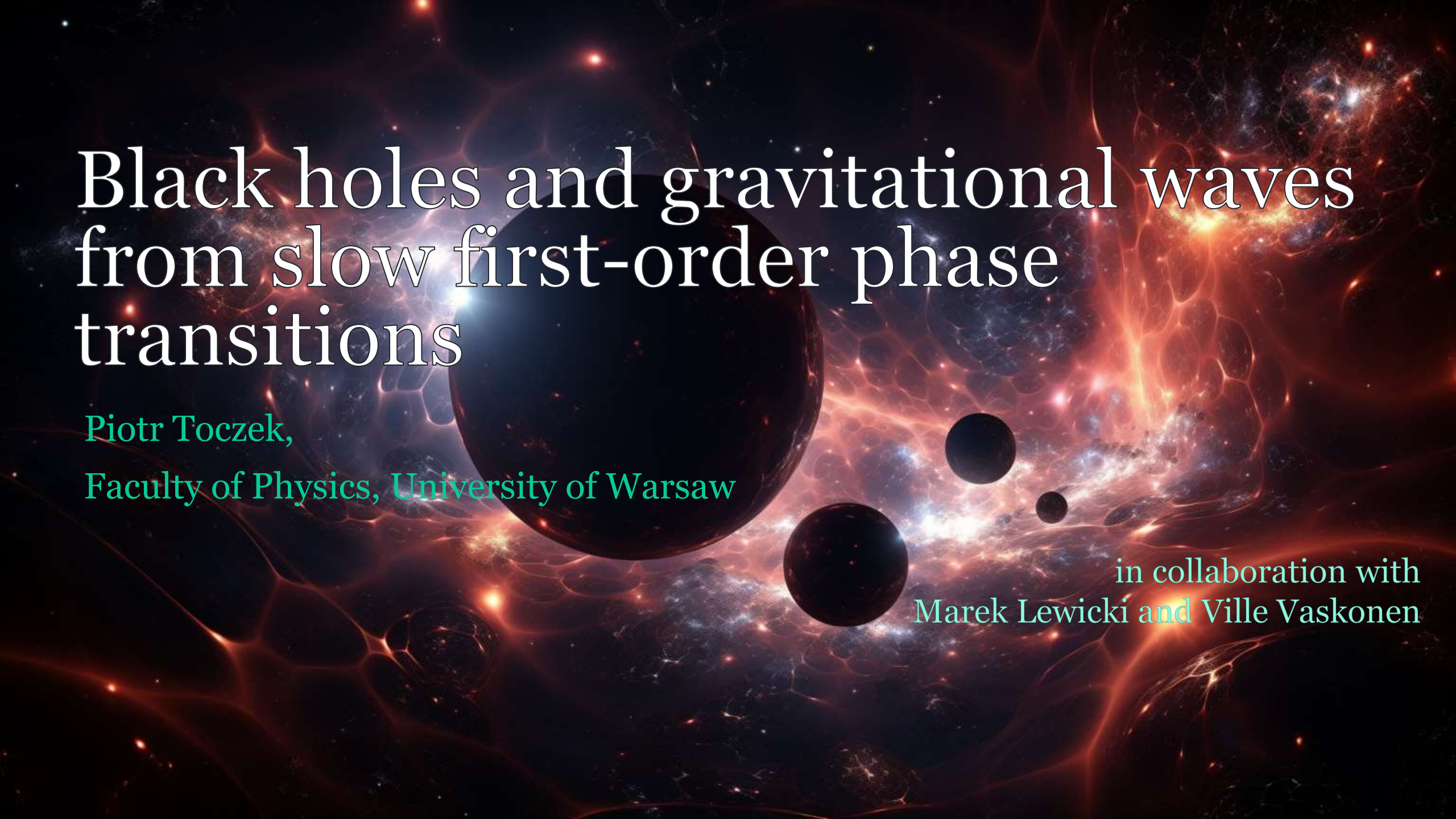


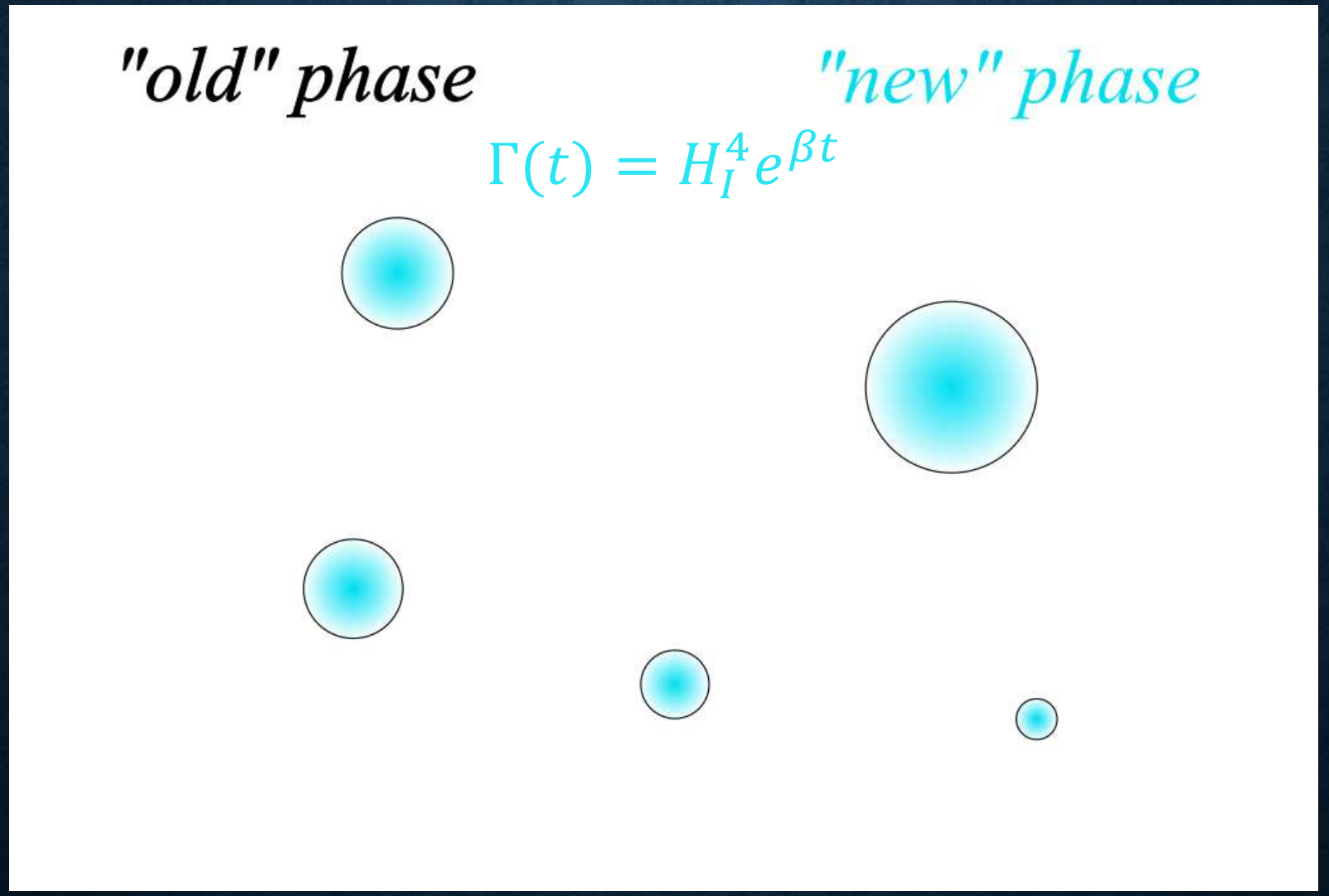
Black holes and gravitational waves from slow first-order phase transitions

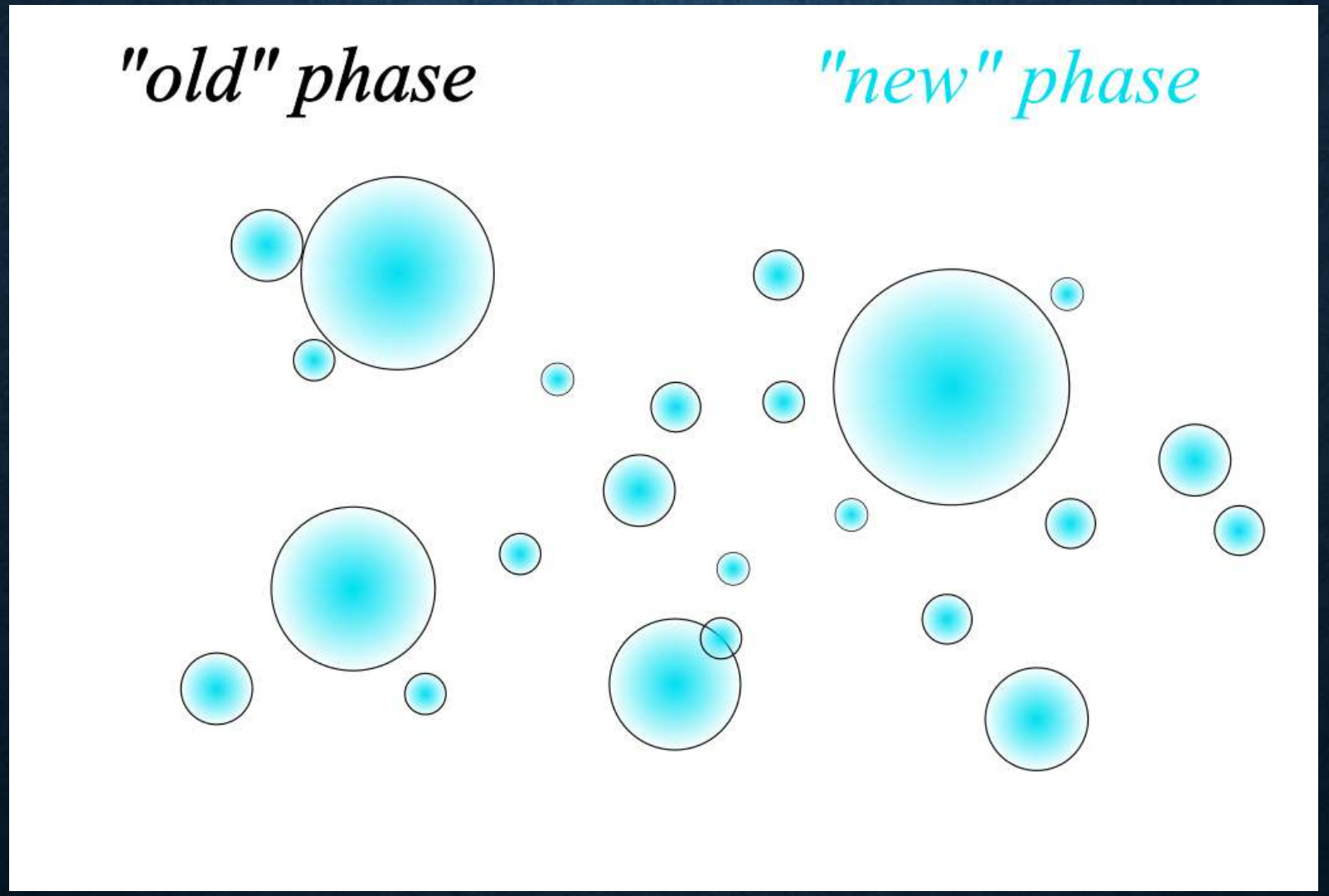
Piotr Toczek,

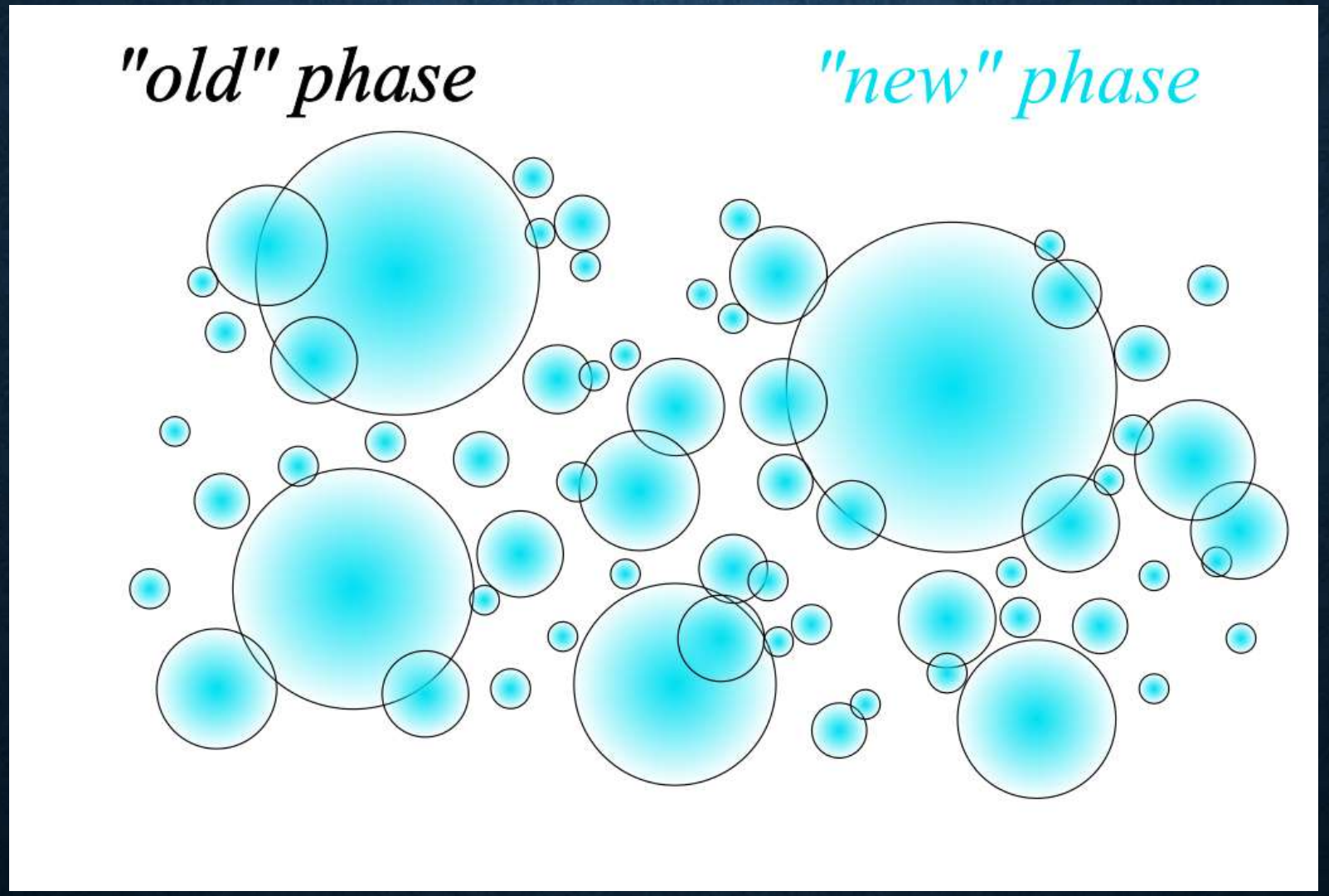
Faculty of Physics, University of Warsaw

in collaboration with
Marek Lewicki and Ville Vaskonen

"old" phase


"old" phase
"new" phase
$\Gamma(t) = H_I^4 e^{\beta t}$


"old" phase
"new" phase


"old" phase
"new" phase

BLACK HOLE FORMATION

Slow, supercooled transition

↓

period of thermal inflation

Statistical nature of bubble nucleation

↓

inhomogeneitites

BLACK HOLE FORMATION

Slow, supercooled transition

↓

period of thermal inflation

Statistical nature of bubble nucleation

↓

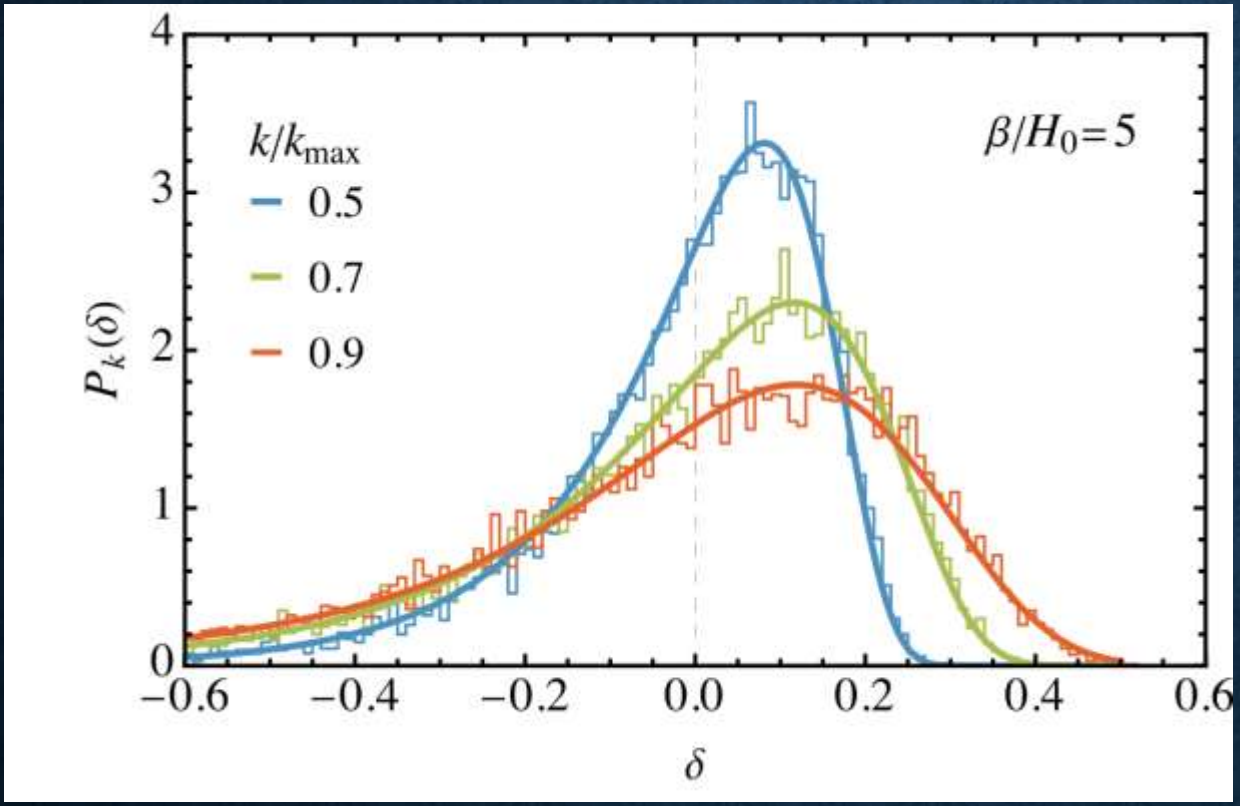
inhomogeneitites

$$\dot{\rho}_r + 4H\rho_r = -\dot{\rho}_v$$

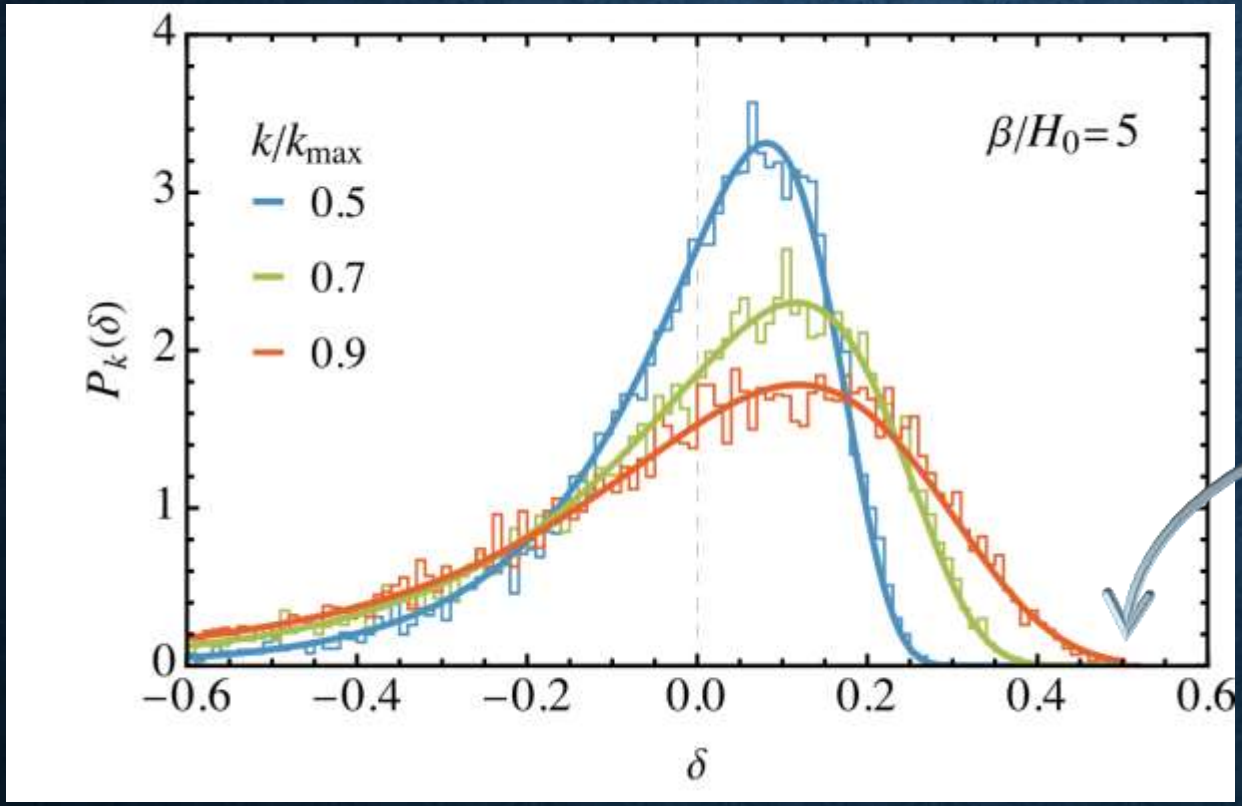
Large fluctuations of energy density

$$\delta = \frac{\rho - \rho_b}{\rho_b}$$

BLACK HOLE FORMATION



BLACK HOLE FORMATION

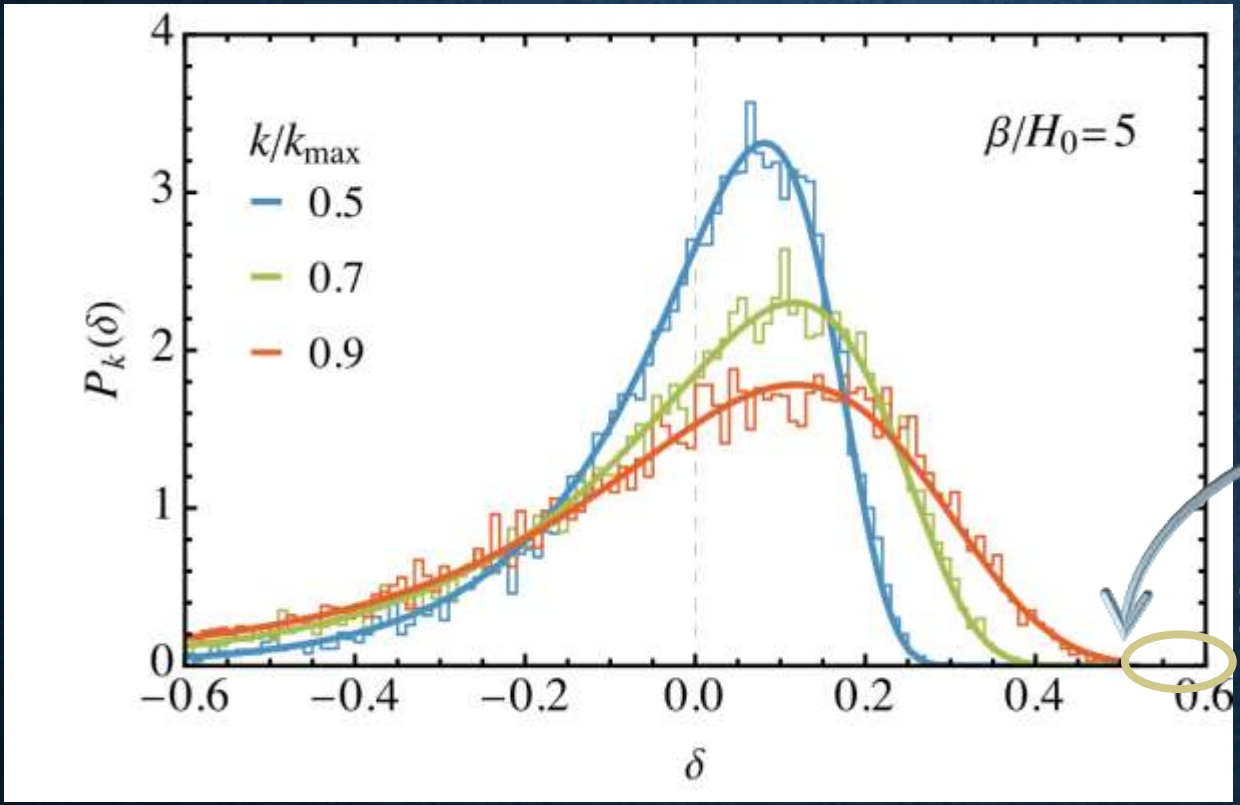


Critical scaling law

$$M(\delta) = \kappa M_k(\delta - \delta_c)^\gamma$$

$$\delta_c = 0.5$$

BLACK HOLE FORMATION



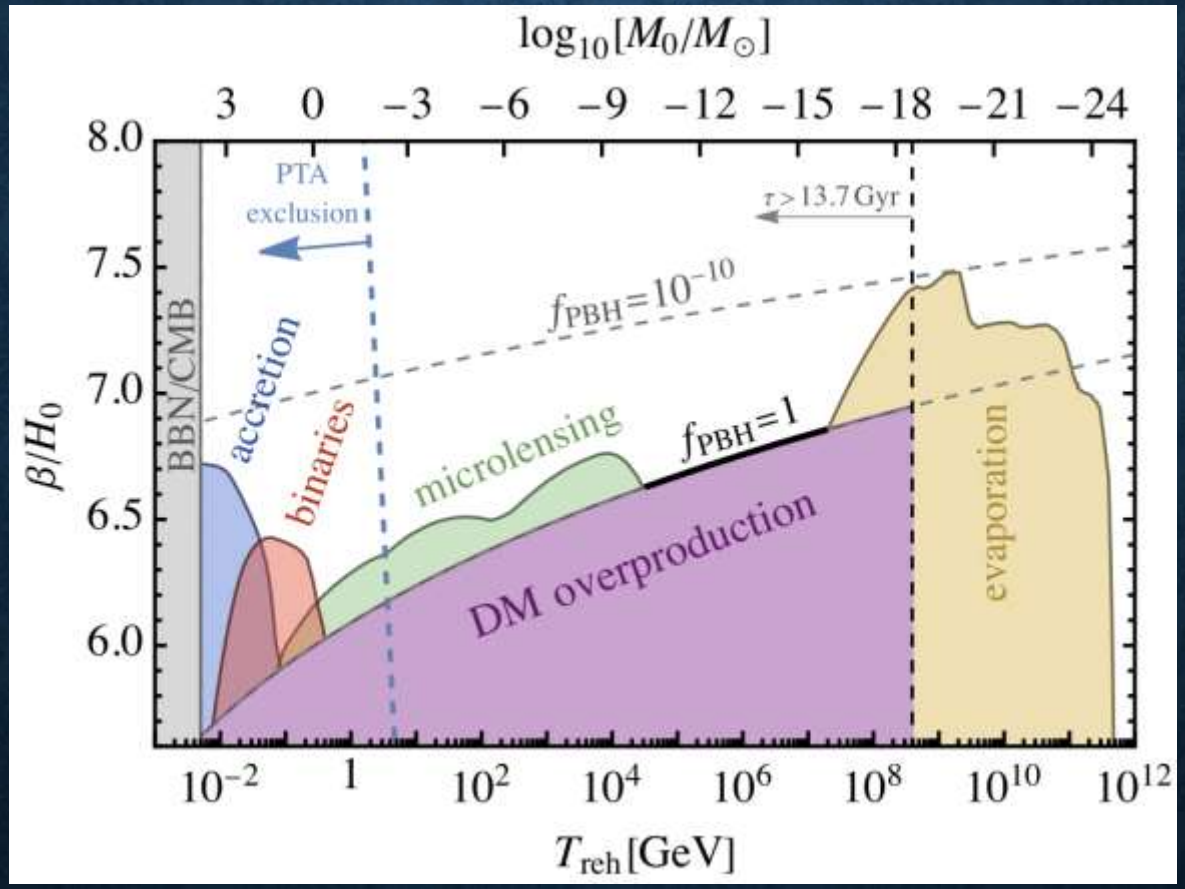
Critical scaling law

$$M(\delta) = \kappa M_k(\delta - \delta_c)^\gamma$$

$\delta_c = 0.5$

PBH formation

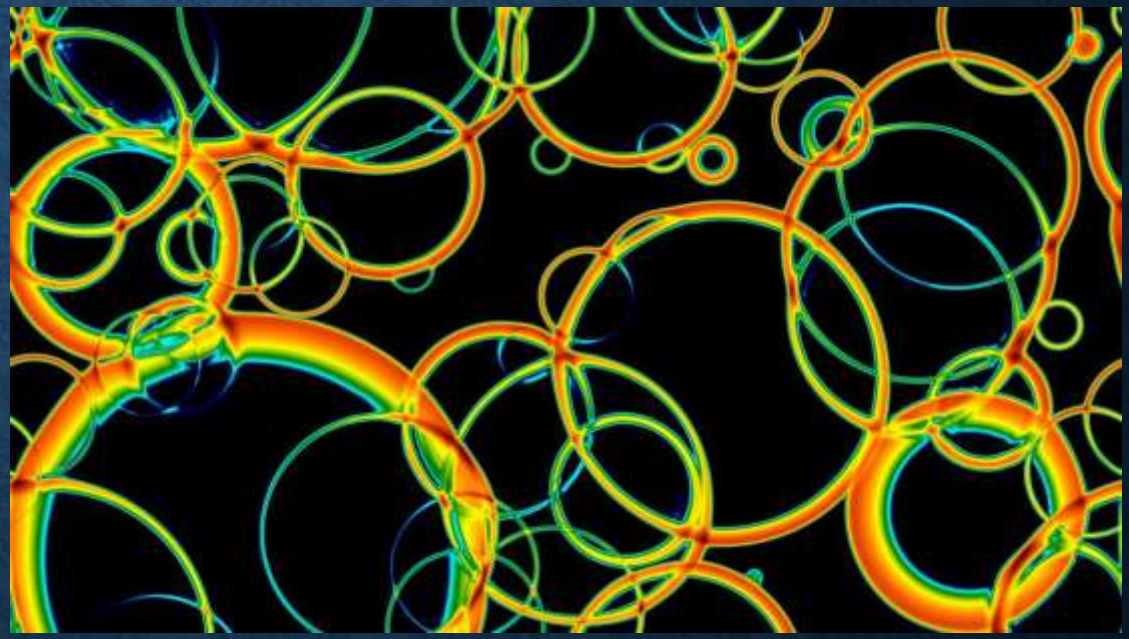
BLACK HOLE FORMATION



GRAVITATIONAL WAVES

During phase transition:

- bubble collisions
- sound waves in plasma



D. Weir, University of Helsinki

GRAVITATIONAL WAVES

During phase transition:

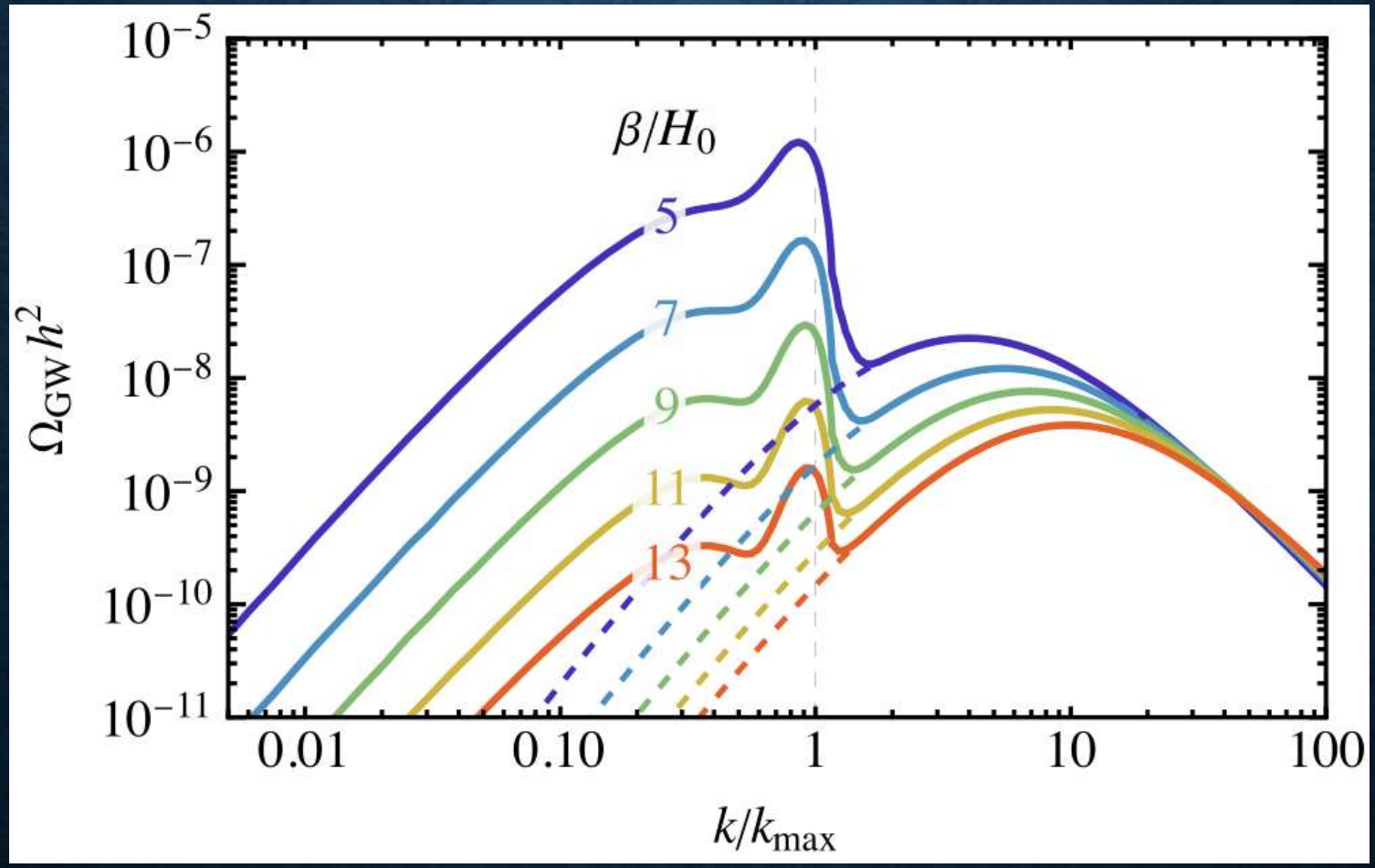
- bubble collisions
- sound waves in plasma

Second order effects?

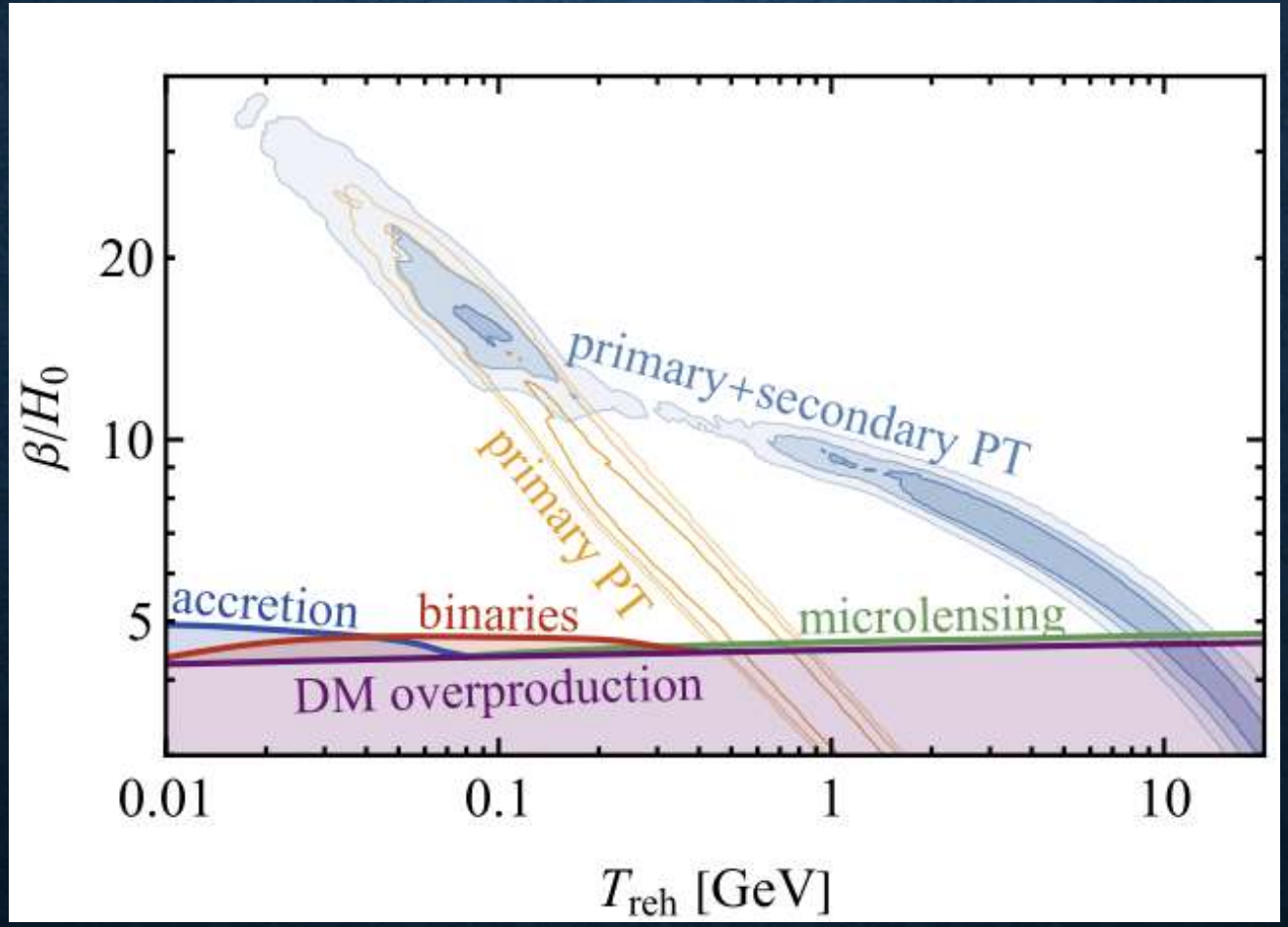
- scalar induced gravitational waves

Energy density fluctuations → GWs

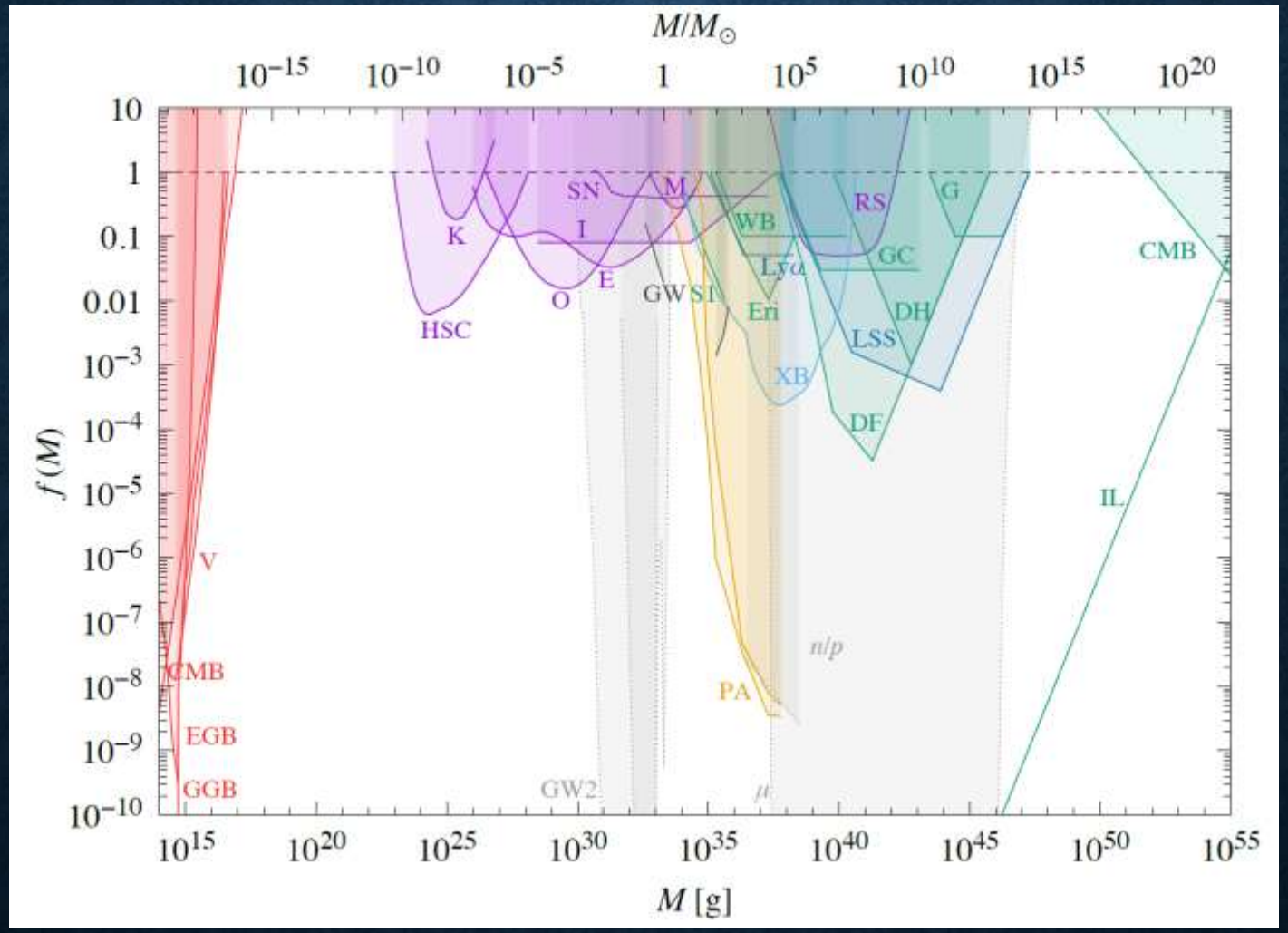
GRAVITATIONAL WAVES



GRAVITATIONAL WAVES

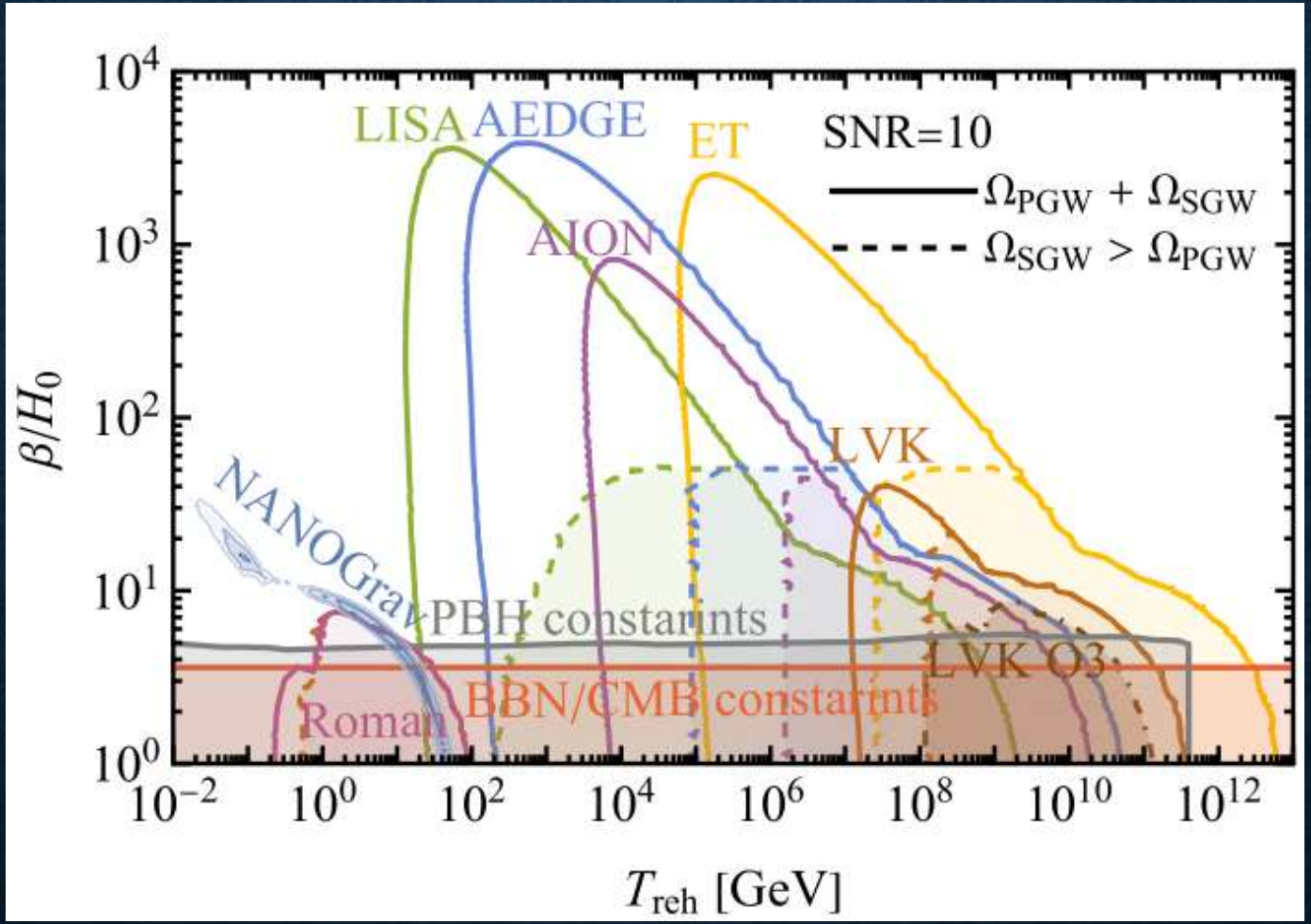


Thank you!

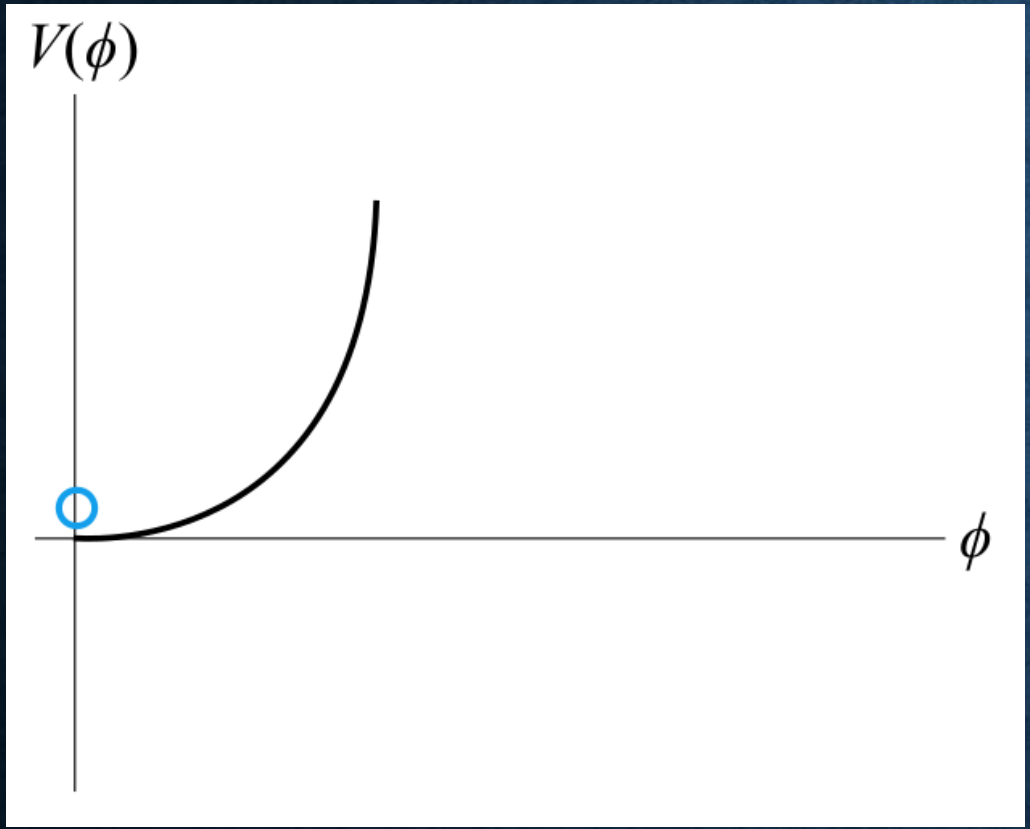


B. Carr, K. Kohri, Y. Sendouda, J. Yokoyama, *Rept. Prog. Phys.* **84** (2021) 11, 116902

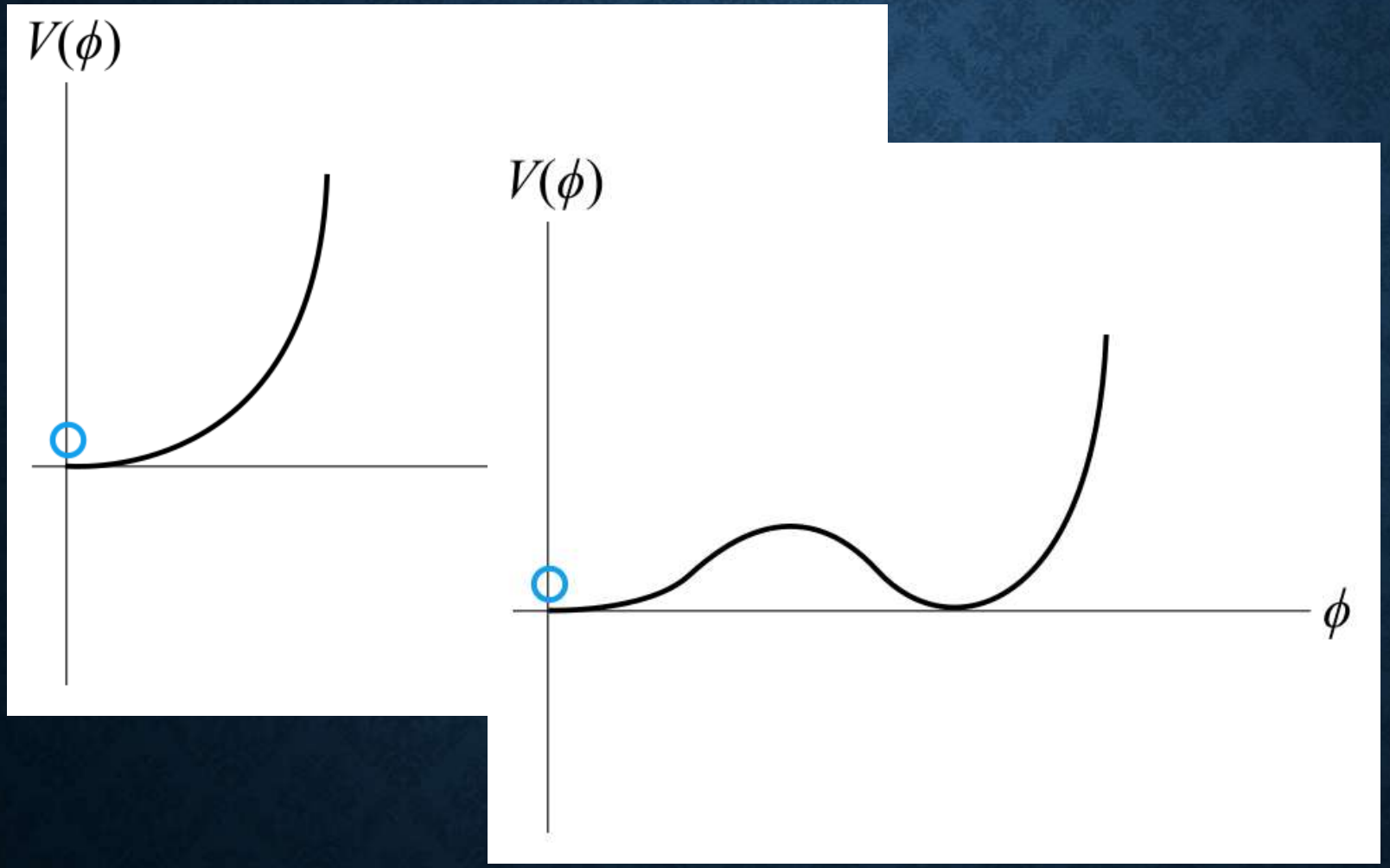
GRAVITATIONAL WAVES



FIRST-ORDER PHASE TRANSITION



FIRST-ORDER PHASE TRANSITION



FIRST-ORDER PHASE TRANSITION