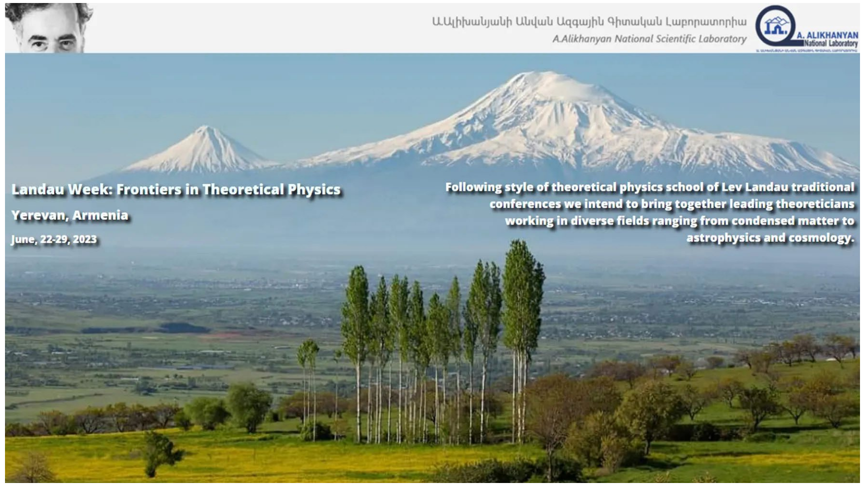

QUANTUM VACUUM EFFECTS IN DE SITTER SPACETIME

TIGRAN PETROSYAN, ARAM SAHARIAN

INSTITUTE OF PHYSICS, YEREVAN STATE UNIVERSITY

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BACKGROUND SPACETIME

- $(D+1)$-dimensional de Sitter spacetime, foliated with time slices having constant negative curvature

  Line element → $$ds^2 = dt^2 - \alpha^2 \sinh^2(t/\alpha)\left(dr^2 + \sinh^2 r\, d\Omega_{D-1}^2\right)$$

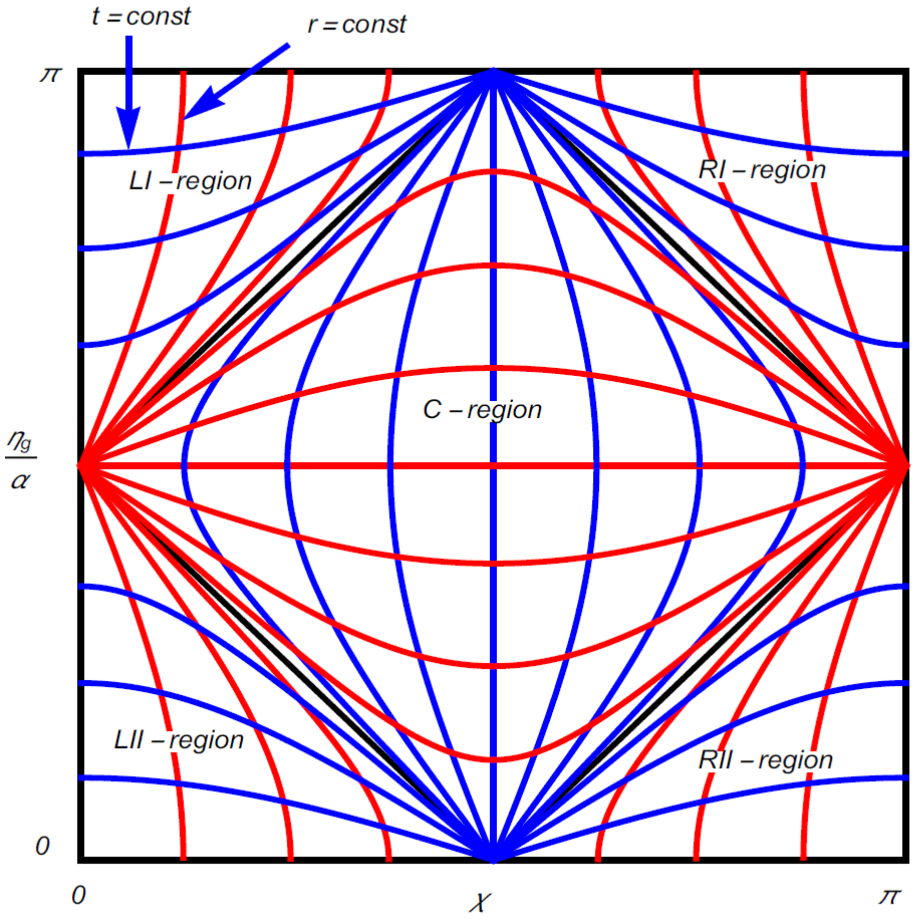
$$R = \frac{D(D+1)}{\alpha^2}$$ → Spacetime curvature

α → Curvature radius

- Coordinates with negative curvature spatial foliation (LI and LII regions)

- Relations with conformal global coordinates

$$\cosh(t/\alpha) = \frac{\cos\chi}{\sin(\eta_g/\alpha)}, \quad \tanh r = -\frac{\sin\chi}{\cos(\eta_g/\alpha)}$$



PROBLEM FORMULATION

- Scalar field φ

field mass	m
curvature coupling parameter	ξ

- Boundary geometry consists of a sphere of radius r_0 with Robin boundary condition (BC)

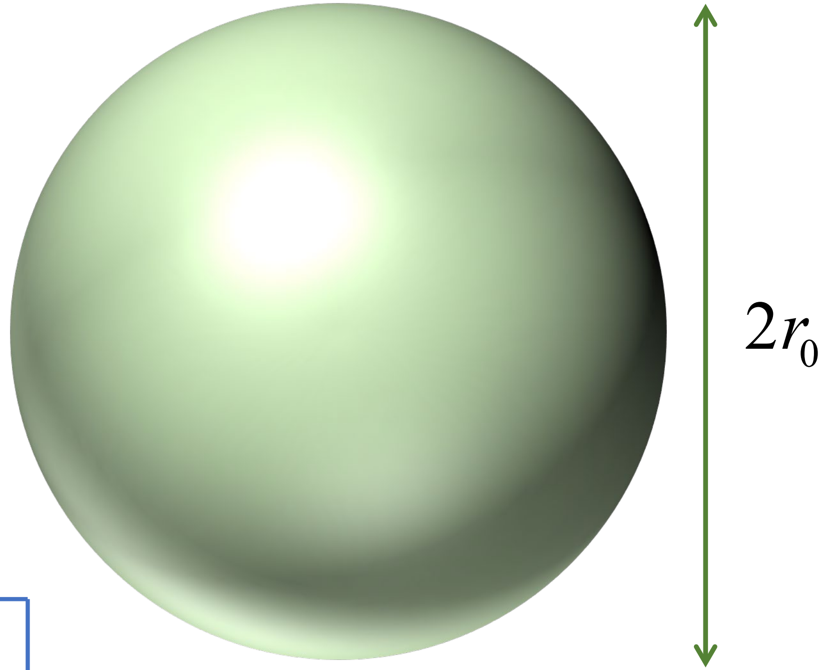
$$\left(A - \delta_{(\mathrm{j})} B \partial_r\right) \varphi(x)\Big|_{r=r_0} = 0$$

$$\mathrm{j} = \mathrm{i}, \mathrm{e}, \quad \delta_{(\mathrm{i})} = 1, \quad \delta_{(\mathrm{e})} = -1$$

- Special case: $B = 0 \longrightarrow$ Dirichlet BC

- Field equation $\left(\nabla_\mu \nabla^\mu + m^2 + \xi R\right) \varphi(x) = 0$

Minimal coupling	$\xi = 0$
Conformal coupling	$\xi = \frac{D-1}{4D}$



SOLUTION SCHEME

- Mode functions
- Conformal vacuum
- Adiabatic vacuum

  → Hyperbolic vacuum

- Hadamard function

$$G(x,x') = \sum_\sigma \left[\varphi_\sigma(x)\varphi_\sigma^*(x') + \varphi_\sigma(x')\varphi_\sigma^*(x) \right] = G_0(x,x') + G_s(x,x')$$

- VEV of the field squared

$$\langle \varphi^2 \rangle = \frac{1}{2} \lim_{x' \to x} G(x,x') = \langle \varphi^2 \rangle_0 + \langle \varphi^2 \rangle_s$$

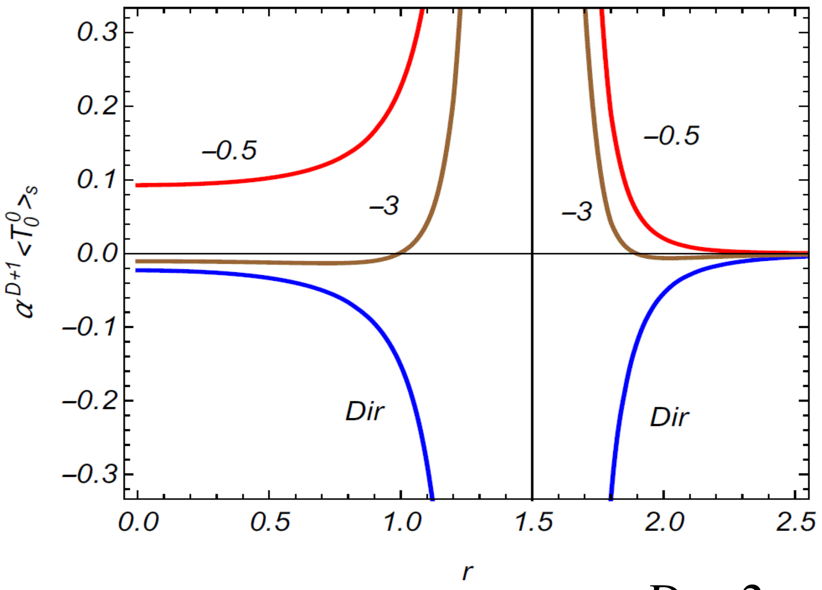
- VEV of the energy-momentum tensor

$$\langle T_{ik} \rangle = \frac{1}{2} \lim_{x' \to x} \partial_{i'} \partial_k G(x,x') + \left[(\xi - 1/4) g_{ik} \nabla_p \nabla^p - \xi \nabla_i \nabla_k - \xi R_{ik} \right] \langle \varphi^2 \rangle = \langle T_{ik} \rangle_0 + \langle T_{ik} \rangle_s$$

- Non-diagonal component corresponds to the energy flux along radial direction

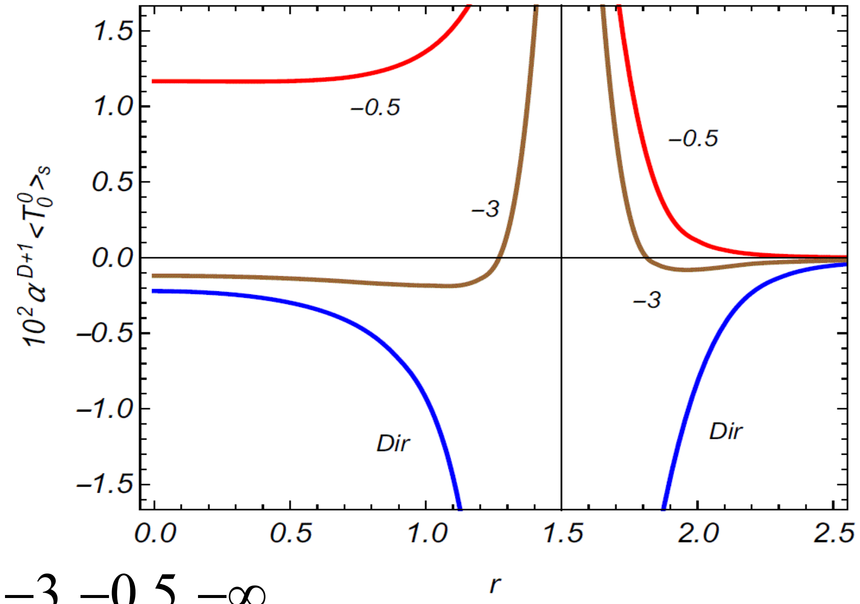
ENERGY DENSITY, ENERGY FLUX

Energy density

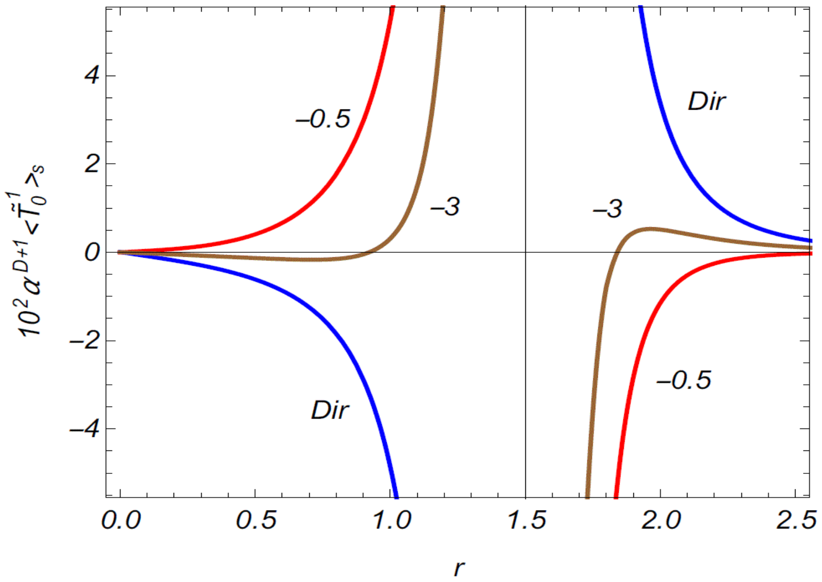


Minimal
$\xi = 0$

Conformal
$\xi = \xi_D$



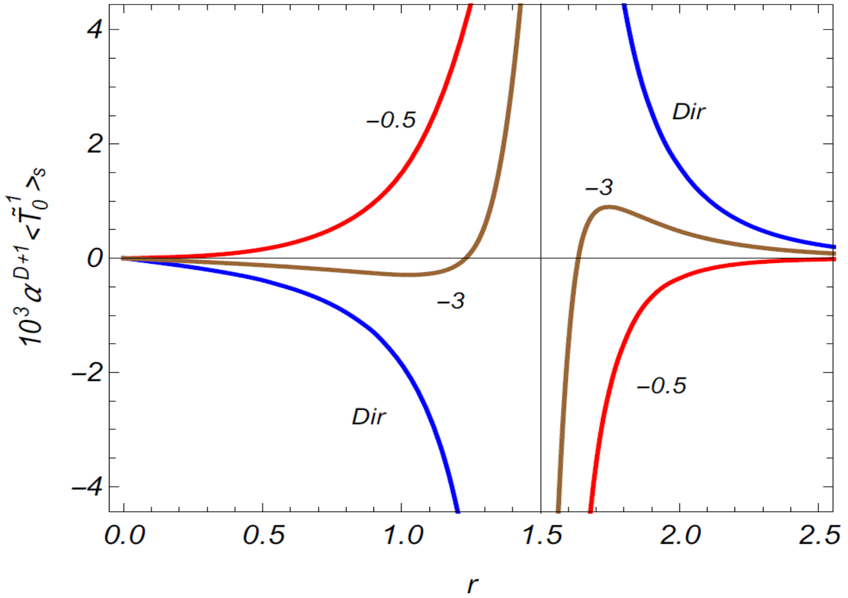
$$D = 3,\ r_0 = 1.5,\ m\alpha = t/\alpha = 1,\ \beta = A/B = -3, -0.5, -\infty$$



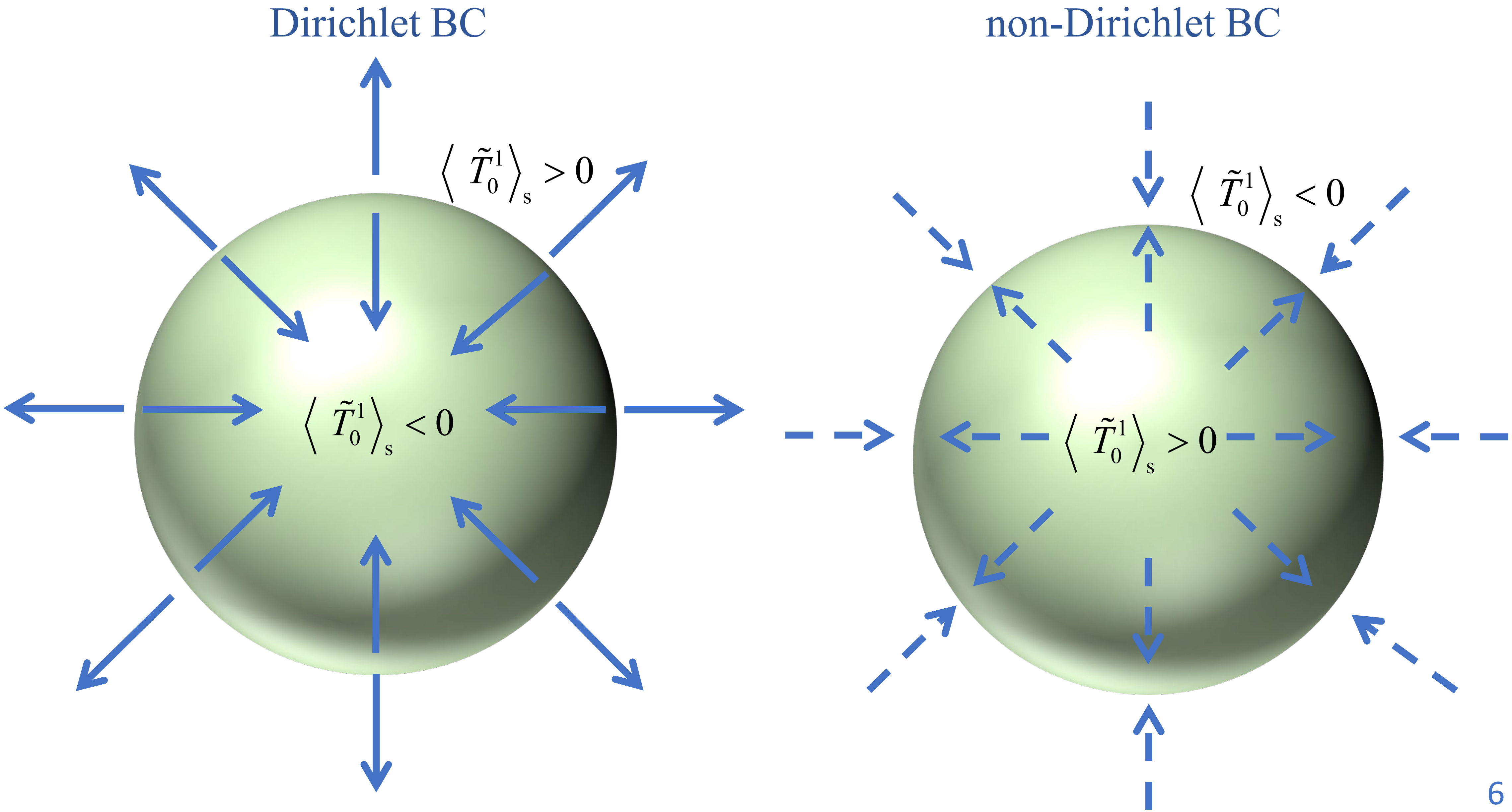
Minimal
$\xi = 0$

Conformal
$\xi = \xi_D$

Energy flux



ENERGY FLUX



Dirichlet BC
$\langle \tilde{T}^1_0 \rangle_s > 0$
$\langle \tilde{T}^1_0 \rangle_s < 0$
non-Dirichlet BC
$\langle \tilde{T}^1_0 \rangle_s < 0$
$\langle \tilde{T}^1_0 \rangle_s > 0$

THANK YOU