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Free energy dependence on spatial geometry for (2+1)-dimensional QFTs

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We consider (2+1)d-QFT at finite temperature on a product of time with a static spatial geometry. Generically, free energy of QFTs on curved spacetime can be very difficult to calculate even for free field theories. For perturbations of flat space we show that free energy difference goes quadratically with perturbation amplitude and may be computed from the linear response of the stress tensor. As an illustration we compute it from holographic duality finding that for strongly coupled CFT at any temperature, and for any perturbation, the free energy decreases. Similar behaviour was also found for free scalars and fermions, and for unitary CFTs at zero temperature from heat kernel method. Similarity between two vastly different regimes of QFT is also commented. This suggesting that (2+1)d-QFT may generally energetically favour a curved spatial geometry. We also treat the deformation in a large wavelength deformation relative to the thermal scale. Then the free energy variation is determined by a curvature correction to the stress tensor and for these theories is negative for small curvature deformations of flat space.

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