Ghost condensation and horizon entropy

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Ghost condensation is the simplest realization of an analogue of Higgs mechanism in gravity and provides a theoretically consistent way to modify gravity in the infrared. After reviewing the basic idea of ghost condensation and its phenomenologies, we revisit three proposals for violation of the generalized second law in the presence of ghost condensation. Two of them, (i) analogue of Penrose process and (ii) semiclassical heat flow, are based on Lorentz breaking effects, by which particles of different species can have different limits of speed. We show that processes in both (i) and (ii) are always slower than accretion of ghost condensate and cannot decrease the total entropy before the accretion increases the entropy. The other proposal is to use (iii) negative energy carried by excitations of ghost condensate. We prove an averaged null energy condition, which we conjecture prevents the proposal (iii) from violating the generalized second law in a coarse-grained sense. Finally, since not only black holes but also cosmology are expected to play important roles towards our better understanding of gravity, we consider a cosmological setup to test the theory. In particular we shall show that the de Sitter entropy bound proposed by Arkani-Hamed, et.al. is satisfied if ghost inflation happened in the early epoch of our universe. We then propose a notion of cosmological Page time after inflation.