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# Thermodynamic equation of state and phase transitions for the spacetime of Friedmann-Robertson-Walker universe

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It is well-known that the spacetime of Friedmann-Robertson-Walker (FRW) universe is a thermodynamic system, where it has temperature, entropy and satisfies the first law of thermodynamics. We recently make a further significant step that we construct the thermodynamic equation of state for the FRW spacetime for the first time, i.e. P=P (V,T) where the gravitational pressure P is directly derived from the unified first law, in fact the gravitational field equation in spherically symmetric spacetime through a first principle study. Furthermore, by using the thermodynamic equation of state, we have discovered three kinds of thermodynamic phase transitions in the FRW spacetime. We also make some investigations on insights into the potential astronomic observations of these phase transitions.

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