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| Title: | Late-time Cosmology in Modified Theories of Gravity: Dual Bouncing and Collapsing Universes |
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| Abstract: | The search for a theory of dark energy beyond the standard model of cosmology falls into two categories: one can introduce an exotic fluid source to model dark energy, such as the quintessence field, or one can extend general relativity by considering a modified theory of gravity to explain the late-time acceleration, such as the scalar-tensor theo- ries or f (R ) theories of gravity. A spacetime-dependent re-scaling of the metric, or con- formal transformation, allows for the modified theories to be recast as Einstein's grav- ity with a scalar field, referred to as the Jordan and Einstein frame representations. Al- though the conformal frames are equivalent, the cosmological evolutions in the frames can be drastically different. Using the conformal correspondence, this thesis explores alternative descriptions of dark energy-driven late-time cosmology through bouncing and collapsing universes. We study f (R ) models which provide an effective descrip- tion of quintessence models of dark energy in the Einstein frame. For a class of viable quintessence models, the Jordan frame universe grows to a maximum size, after which it collapses and eventually approaches a singularity, while the Einstein frame universe keeps on expanding. We show that the standard ΛCDM cosmology and all quintessence models of dark energy can alternatively be seen as bouncing or collapsing universes driven by scalar-tensor theories. These dual descriptions of the late-time universe are stable against linear perturbations. We further study the expansion-collapse duality in a quantum gravity framework. As the collapsing universe becomes sufficiently small, it expectedly develops significant quantum fluctuations; more surprisingly, its dual ex- panding universe also develops similar quantum features, regardless of its size. Our re- sults suggest that the rise in quantum characteristics is a frame-independent effect. The expansion-collapse duality between conformal frames has potential implications for the study of perturbations and quantum fluctuations in a large expanding universe. |
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