Title:	Nonlinear spherical perturbations in quintessence models of dark energy
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Abstract:	Observations have confirmed the accelerated expansion of the universe. The accelerated expansion can be modelled by invoking a cosmological constant or a dynamical model of dark energy. A key difference between these models is that the equation of state parameter w for dark energy differs from −1 in dynamical dark energy (DDE) models. Further, the equation of state parameter is not constant for a general DDE model. Such differences can be probed using the variation of scale factor with time by measuring distances. Another significant difference between the cosmological constant and DDE models is that the latter must cluster. Linear perturbation analysis indicates that perturbations in quintessence models of dark energy do not grow to have a significant amplitude at small length scales. In this paper we study the response of quintessence dark energy to non-linear perturbations in dark matter. We use a fully relativistic model for spherically symmetric perturbations. In this study we focus on thawing models. We find that in response to non-linear perturbations in dark matter, dark energy perturbations grow at a faster rate than expected in linear perturbation theory. We find that dark energy perturbation remains localised and does not diffuse out to larger scales. The dominant drivers of the evolution of dark energy perturbations are the local Hubble flow and a supression of gradients of the scalar field. We also find that the equation of state parameter w changes in response to perturbations in dark matter such that it also becomes a function of position. The variation of w in space is correlated with density contrast for matter. Variation of w and perturbations in dark energy are more pronounced in response to large scale perturbations in matter while the dependence on the amplitude of matter perturbations is much weaker.
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