Contribution ID: **18** Type: **Contributory Talks**

Cosmological bounces in spatially flat FRW spacetimes in metric f (R) gravity

Thursday 29 January 2015 15:00 (15 minutes)

1)Brief introduction to cosmological bounce scenario, an alternative to the singular big-bang cosmology.
2)Brief introduction to f(R) gravity: Motivations, Action and field equation, stability issue, conformal equivalence to GR with a scalar field, Einstein frame description.
3)Analysing cosmological bounce in the framework of f(R) gravity: General bouncing condition for FRW metric with k=+1,-1 and 0(we specifically show that a bounce is possible even for k=0, unlike in GR); a general condition for for any f(R) to support a matterless bounce(this is also notably different from GR, where a matterless bounce is impossible); short discussion on stability analysis in our case; analysis of the bounce in Einstein frame(a bounce in the original frame does not necessarily mean a bounce in the conformal Einstein frame)
4)Formulating a system of coupled differential equation in the Einstein frame for the quantitative treatment of the bounce; numerically solving the system to see the behavior of the dynamical quantities in the Einstein frame, and then going back to the original(Jordan) frame to find the actual picture.
4)Evolution of scalar cosmological perturbation through the bounce: Formulating the scalar perturbation evolution equation in presence of a hydrodynamic equation and a scalar field under the framework of GR; solving this to find out the behavior of the scalar perturbations in the Einstein frame, and then going back to the Jordan frame to see the actual picture.

Summary

The cosmological bounce is an alternative paradigm to big-bang cosmology, in which the universe never hits the singularity, but a contracting universe contracts to a certain minimum size and is then followed by an expanding universe. It is well established that in GR bounce can occur only for k=+1 case of the FRW solution, and that too in presence of some form of matter(the most familiar is a scalar field driven bounce). However, it was noted that in higher order gravity theories, bounce may be possible for k=0 also.

The bounce conditions for the general FRW solutions ($H = 0, \dot{H} > 0$) can be worked out for from the f(R) field equations. We are specially interested in the case $k = 0$ as this is notably different from GR. It is seen that in this case a matterless bounce is possible whenever $Rf' - f$ has a positive root. In particular for a form of $f(R) = R + \alpha R^n$ a matterless bounce is impossible, and also for a matter bounce $\alpha < 0$.

For a quantitative analysis it is helpful to go to the Einstein frame via the conformal transformation $g_{\mu\nu} \rightarrow f'(R)g_{\mu\nu}$, where the theory can be mapped into a GR with an extra minimally coupled scalar field $\phi = \sqrt{\frac{3}{2\kappa}} \ln f'(R)$ in a potential $V(\phi) = \frac{Rf'-f}{2\kappa f^2}$.
We form a system of coupled differential equations in the Einstein frame and solve it numerically for R^2 gravity by choosing suitable initial conditions. It is seen that though we are considering a bounce, the bounce is absent in the Einstein frame. A bounce in one frame does not imply a bounce in other, and only on specific conditions we get bounce in both the frames simultaneously.

Next we consider the evolution of scalar metric perturbation through such a scenario. In the Jordan frame there are two Bardeen potentials(gauge invariant scalar perturbation d.o.f.), whereas in Einstein frame there is only one. Also, in Einstein frame the theory is ordinary GR so it is easier to derive the perturbation equations. We have solved the perturbation equations in the Einstein frame by choosing suitable initial conditions, and then went back to the Jordan frame via well established relations between Jordan frame and Einstein frame Bardeen potentials. A number of interesting cases, both for symmetric and asymmetric bounce, is considered.

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