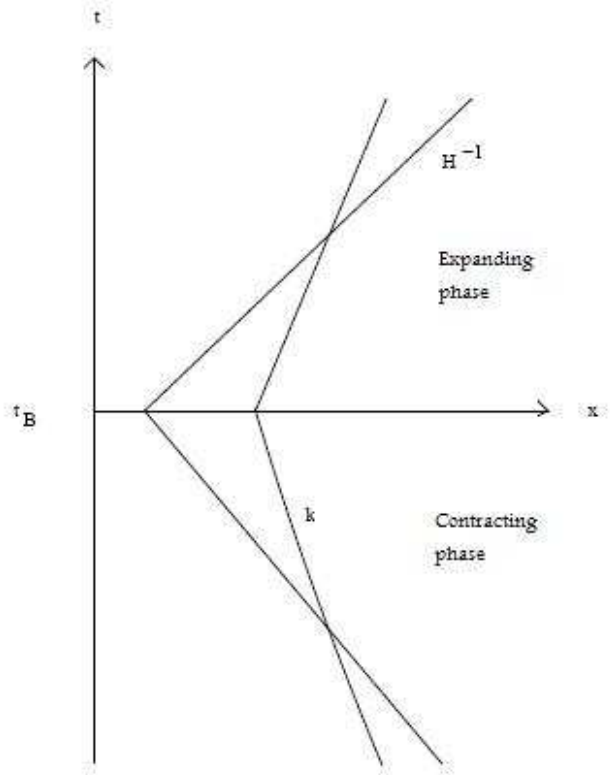

Fig. 3. The plot shows the evolution of the Hubble radius H^{-1} and of a fixed comoving scale, the bounce taking place at $t = t_B$. Adapted from Brandenberger (2004).

expansion such that $\ddot{a} > 0$ and $\dot{a} > 0$ (which is the case of inflation), or through a long decelerated phase of contraction before the bounce, characterized by $\ddot{a} < 0$ and $\dot{a} < 0$.

Regarding the generation of primordial perturbations in nonsingular models, during the contracting phase the Hubble radius H^{-1} contracts faster than the physical length corresponding to a fixed comoving scale k (see Figure 3). Quantum vacuum fluctuations generated causally on sub-Hubble scales in the contracting phase are assumed to be the seeds of the inhomogeneities observed today. The scale of these fluctuations is amplified and evolves according to GR during the (long) time when it is larger than the Hubble radius.

Finally, if the bounce is such that $a_0 \gg \ell_{\rm Pl}$ there is no Transplanckian problem.

3. AN EXAMPLE

Having shown in the previous section that a nonsingular model may in principle furnish a solution to the problems of standard cosmology, let us review in this section a specific model of this type, and what kind of predictions can be obtained from it. The

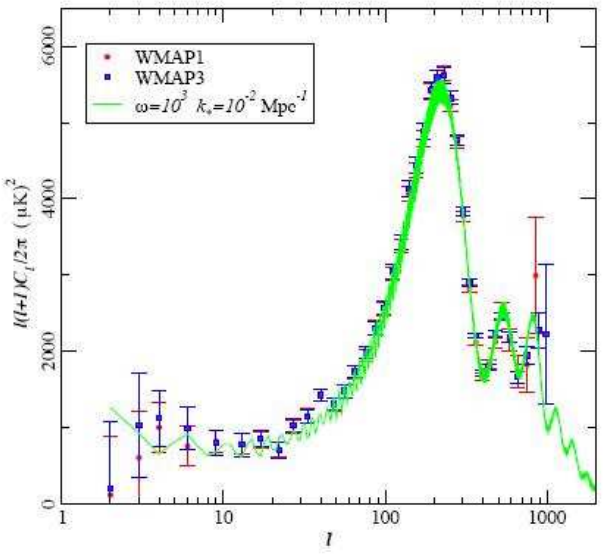

Fig. 4. The plot shows the multipoles C_ℓ for a typical bouncing model, as well as WMAP data (Falciano et al. 2008).

model in question was developed in Peter & Pinto-Neto (2008), in the framework of GR plus a perfect fluid with equation of state $p = \omega\rho$, the spacetime geometry being of the FLRW type. The quantization of both the background and the perturbations of this model following the Bohmian approach (see Peter & Pinto-Neto 2008 for details), furnishes for the evolution of the background

$$a(\tau) = a_0 \left[1 + \left(\frac{\tau}{T_0}\right)^2\right]^{1/[3(1-\omega)]},$$

with $d\eta = [a(\tau)]^{3\omega-1} d\tau$, and η is the conformal time. This solution has no singularities and tends to the classical solution when $\tau \to \pm\infty$. An analysis of the perturbations shows that they behave exactly as shown in Figure 3. The result obtained in Peter & Pinto-Neto (2008) for the power spectra is

$$n_s = 1 + \frac{12\omega}{1+3\omega}, \qquad n_T = \frac{12\omega}{1+3\omega},$$

in such a way that both the scalar and the tensor spectrum tend to a scale-invariant spectrum in the dust limit. Finally, a fit of the amplitude of the perturbations to the CMB data yields $a_0 \approx 1000\ell_{\rm Planck}$, thus avoiding the Transplanckian problem. Notice also that the model predicts a tensor to scalar ratio of $T/S \propto \sqrt{n_s - 1}$, while inflationary models tipically predict a linear relation.