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Primordial Bubbles within Primordial Bubbles

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Abstract. Two consecutive, distinct episodes of phase transition occurring during inflation may nucleate two generations of bubbles, one inside the other. We design a model of inflation that realizes this sequence and yields bubble spectra that are bimodal and tunable functions of phenomelogical parameters in turn combinations of microphysical parameters. We argue in favor of a tuning of the parameters such that the outer and earlier generation of bubbles becomes hundreds of Mpc/h in diameter (like the local Hubble bubbles of the literature) whereas the inner and later generation becomes tens of Mpc/h in diameter (like the observed large scale voids).

A cosmological constant or its modern and complex version of quintessence explain the SN Ia results. Among the alternative explanations noteworthy is the removal of the implicit assumption of uniformity for the Hubble parameter (Goodwin 1999 et al.; Tomita 2000), as in the case of the occurrence of a local Hubble bubble (LHB) sized hundreds of h^{-1} Mpc in which we might be embedded. The LHB, a spherically symmetric underdensity displaying two levels of the Hubble parameter (larger internally by $\approx 10\%$ than externally) is compatible both with bulk motions and with the tendency of the Hubble parameter to be larger at small distances than at large ones. The concept also resonates with the "bubbly" scenario (Occhionero, Santangelo & Vittorio 1983; Amendola & Occhionero 1993; Occhionero et al. 1997), proposed however for the smaller scales (tens of h^{-1} Mpc) of the observed voids. Since the underlying idea is that the voids we observe now are the primordial bubbles of an inflationary phase transition (IPT) inflated to such large diameters, the natural step is then to assume that also the $\mathcal{O}(100\ h^{-1}$ Mpc) LHB's are generated by an IPT. They however must differ from their smaller siblings in that they are at the same time capable of harboring the latter in their interiors as a second generation of bubbles. It is also tantalizing to relate these LHB's to the power observed on the same scales. The physical scheme for such a model is very easy to construct (Occhionero & Amendola 1994) in a *two-field* inflation with a potential $U(\omega,\psi)$, which yields slow rolling along ω and tunnelling along ψ. It is enough to carve in U two non–degenerate channels directed along ω. Let now the energy difference between them, ΔU, depend on ω. Then, as ω rolls down $U(\omega,\psi)$, ultimately the rate of tunnelling depends on time. Furthermore, postulating a sign change of ΔU at some ω_*, not only do we have *two* epochs of intense tunnelling, but also i) that the second generation bubbles are born within the first generation ones and ii) that, as ΔU=0, the Euclidean action becomes singular and the first transition stops abruptly short of completion. The size of the smallest bubbles of the first generation is a tunable parameter which will be set to be $\mathcal{O}(100\,h^{-1}$

Mpc), as mentioned. If we label time with the number N of e-foldings to the end of inflation, the essential parameter is the N_* at which the change of sign of ΔU occurs: it turns out that $N_* \approx 55$ if $N_{HOR} = 60$. It is through this sign inversion that two distinct, but very close epochs of bubble formation are possible, on the large scales ($> 100h^{-1}$Mpc, $N > N_*$) and on the small ones ($\approx 10 - 100h^{-1}$Mpc, $N < N_*$). In the matter dominated era, the evolution of such configurations (conveniently described by the Tolman solution) is stronger the earlier the horizon entrance and consists of the deepening of a spherical cavity and of the steepening of the surrounding, slightly overcomoving shell. We assume that for the smaller bubble generation the outer shell may shock and yield a burst of galaxy formation at large redshift.

Complete references, formalism and results will be given elsewhere.

In conclusion, since astronomical observations seem to suggest a phenomenology of large scale voids occurring inside still larger underdensities, we have shown that both features can be explained in canonical inflation and by a single physical mechanism, a primordial first order phase transition, where a free parameter is the scale at which the potential difference between the two channels vanishes. From previous work on one nucleation bursts (Amendola, Baccigalupi & Occhionero 1998), we may expect that the large bubble generation leave a Sachs–Wolfe signal with angular size of 1^o. This power is added to the spectrum around the first Doppler peak at $\ell \approx 200$ (de Bernardis et al. 2000; Lange et al. 2000). Furthermore, the signal on the CMB maps consists of a highly non–Gaussian Poisson distribution of cold spots. From the lack of non–Gaussianity (Corasaniti, Amendola & Occhionero 2000), extrapolating up to the horizon work at smaller scales , we estimate that the product of the depth $\delta\rho/\rho$ times the fraction of space occupied by the underdensities must not exceed $\approx .0002$, suggesting that the outer shell may not have reached yet the conditions for enhanced galaxy formation, unlike the case of the inner bubbles.

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