STRUCTURE FORMATION SEEDED BY COSMIC STRINGS

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We describe the results of high-resolution numerical simulations of structure formation seeded by a cosmic string network with a large dynamical range taking into account, for the first time, modifications due to the radiation-matter transition [1]. The resulting linear power spectrum of density perturbations is calculated with either cold or hot dark matter backgrounds and compared with the linear power spectrum inferred from various galaxy surveys [2]. Finally, we investigate the performance of cosmic string models in open universes and those with a non-zero cosmological constant. This direct numerical approach marks a considerable quantitative advance by incorporating important aspects of the relevant physics not included in previous treatments.

For flat models with $\Omega_\Lambda = 0$, strings induce an excess of small-scale power and a shortage of large-scale power, that is, this model requires a strongly scale-dependent bias (or even an antibias on small scales). This is not necessarily a fatal flaw on small scales because such excess power can be readily eliminated in a mixed dark matter model. On large scales the problem is less tractable and significant biasing is required. However, unlike inflation, defect models have never been wedded to an $\Omega = 1$ cosmology. The generalization to open or Λ-models tends to remove the excess small-scale power found in cosmic string models with $\Omega = 1$ and $\Omega_\Lambda = 0$, while also compensating for the shortage of large-scale power [3]. For open or Λ-cosmologies with $\Omega \approx 0.2$–0.3, the string + CDM power spectrum has a bias on large scales which is always close to unity and, overall, it is much

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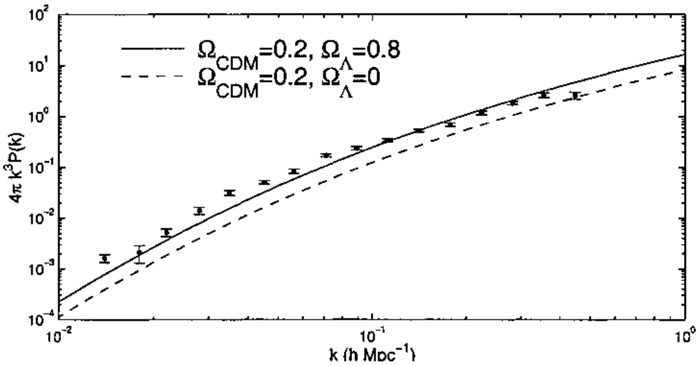

Figure 1. The linear power spectra induced by cosmic strings in CDM for different background cosmologies. Here, we use $h = 0.7$ and $G\mu_6 = 1.7$ [4]. The data points with error bars are the reconstructed linear spectrum by Peacock and Dodds [2].

less scale-dependent. We find that for $\Gamma = \Omega h = 0.1$–0.2, both $\sigma_{8(\mathrm{sim})}$ and the shape of the power spectrum induced by cosmic strings matches observations very well. The HDM power spectrum seems to require a strongly scale-dependent bias either on small or large scales, but we note that a high baryon fraction may help to increase small-scale power. Further investigation using a hydrodynamical code will be required to determine whether galaxies can form early enough. A key feature of all these string-induced power spectra is the influence of the slow relaxation to the matter era string density from the much higher radiation string density. Even by recombination in an $\Omega = 1$ ($h = 0.7$) cosmology, the string density is more than twice its asymptotic matter era value to which we normalize on COBE scales. This implies that the string model provides higher than expected large-scale power around $100h^{-1}$Mpc and below. Interestingly, this can also be expected to produce a significant Doppler-like peak on small angle CMB scales, an effect noted in ref. [4] and confirmed in ref. [5] using a simplified phenomenological model for cosmic strings. These results for the cosmic string scenario are encouraging.

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