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COMMENT ON "STRING-DOMINATED UNIVERSE(SDU)"

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Theoretical prejudice favors the flat(k=0) cosmology, and the inflationary Universe scenario implements this prejudice in a natural way. For the k=0 model $\Omega\,(\equiv\rho_{TOT}/\rho_{crit}\,;\,\rho_{TOT}=\rho_{NR}+\rho_{VAC}+\rho_R+\rho_S(+\rho_{NET}))=1$. However, observational data suggests: $\Omega_{OBS}\simeq$ '0.2 ± 0.1', where '±0.1' indicates the range of values reported. This discrepancy is known as the 'Ω-problem.' A number of solutions have been suggested: Ω_{OBS} is determined by assuming that light (i.e.,galaxies) traces mass--perhaps this assumption is not valid; Ω_{OBS} is not sensitive to a smoothly-distributed component of mass density--perhaps most of the mass density resides in a smooth component($\Omega_{SMOOTH}=1-\Omega_{NR}\simeq$ '0.8 ± 0.1').[1] Candidates for the smooth component include: relativistic particles[1] (ρ_R), a relic cosmological term[1] (ρ_{VAC}), and in a recent letter Vilenkin[2] has suggested fast-moving strings(ρ_S) or a tangled network of strings (ρ_{NET}).

There is another equally important difficulty with the k≠0 model-- the growth of density perturbations needed to form structure in the Universe. Linear density perturbations can only grow while the Universe is matter-dominated ($\delta\rho_{NR}/\rho_{NR}\propto a(t)$). The Universe becomes matter-donminated when the cosmic scale factor $a=a_{eq}\simeq 3\times10^{-5}(\Omega_{NR}h^2/\theta^4)^{-1}$, where $H_0=100h\ \mathrm{kms^{-1}Mpc^{-1}}$, $\theta=T_\gamma/2.7K$, $a(\mathrm{today})=1$. In a k≠0 or a SDU, perturbations cease growing roughly when the Universe becomes ~~string or~~ curvature-dominated($\rho_{NR}=\rho_S$ or k/a^2): $a_S\simeq(\Omega_{NR}^{-1}-1)^{-1}$. Therefore the total growth factor for linear density perturbations is: $\gamma\simeq 3\times10^4\,\Omega_{NR}^2h^2/\theta^4$. [If the NR component is baryons, then perturbations cannot grow until after decoupling($a_D\simeq1500^{-1}$) and $\gamma\simeq1500\,\Omega_{NR}$.] Thus for smaller Ω_{NR} larger initial perturbations are needed, in turn implying larger anisotropies in the cosmic background radiation(CBR)-- this is called the 'lo-Ω squeeze.' The smoothness of the CBR rules[3] out all baryon-dominated models and 'hot' or 'cold' dark matter models with $\Omega_{NR}h \lesssim 0.3$.

My main point is that while the SDU addresses the 'Ω-problem,' it does not address and for fast-moving strings is actually worse than the k$\neq$0 model with regard to the 'lo-Ω squeeze.' In contrast, the $\rho_R \neq 0$ and $\Lambda \neq 0$ models are essentially as good in this regard as the $\Omega_{NR}=1$ model. ...t-mov... $\rho_S \propto 1/t\,a(t)$; I have numerically integrated the equations for the evolution of $a(t)$ and of $\delta\rho_{NR}/\rho_{NR}$. In the SDU the growth of $\delta\rho_{NR}/\rho_{NR}$ from decoupling until today is significantly less than in a k$\neq$0 model. Since k$\neq$0 models with $\Omega_{NR}h \lesssim 0.3$ are ruled out, SDU models with $\Omega_{NR}h \lesssim 0.5$ are also ruled out (both have a growth factor of $\lesssim 700$ since decoupling). All baryon-dominated SDU models are ruled out. The reason for the difference between the k$\neq$0 model and the SDU is easy to understand. When $\rho_{NR} \gg \rho_S$, $a \propto t^{2/3}$ and $\rho_S \propto a^{-2.5}$, whereas $k/a^2 \propto a^{-2}$. This means the transition from NR to string-domination takes longer (since $\rho_S/\rho_{NR} \propto a^{1/2}$ and not $\propto a$), and therefore must start earlier [compare the estimate for $a_S \simeq (\Omega_{NR}^{-1} - 1)^{-1}$ with the actual numerical result for a_S]. One other minor point; Vilenkin claims that the SDU helps to ease the Hubble parameter-age dilemma. The SDU is ~~not much~~ better than a $\Omega_{NR}=1$ model, worse than a k$\neq$0 model, and ~~much worse than~~ not nearly as good as a $\Lambda \neq 0$ model ... $H_0 t_0$ is

In sum, there are two difficulties with k$\neq$0 models--that of aesthetics and that of formation of structure. The SDU only addresses the first. With regard to the second the SDU is ... worse (ρ_S than the k$\neq$0 model.

The SDU with a network of strings ($\rho_{NET} \neq 0$) is equivalent to a k$\neq$0 model since $\rho_{NET} \propto a^{-2}$