Cosmic Superstrings in Warped Spacetime

Sarah Chadburn
Durham University
Work with Ruth Gregory & Tasos Avgoustidis

04/04/2012

Why study cosmic strings?

Warped spacetime

Modelling cosmic string motion in warped spacetime

The formation of cosmic strings

- GUT models
- String theory models $\longrightarrow$ brane inflation $\longrightarrow$ cosmic *super*strings

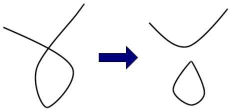
What a cosmic string network might look like

(network)

Martins and Shellard

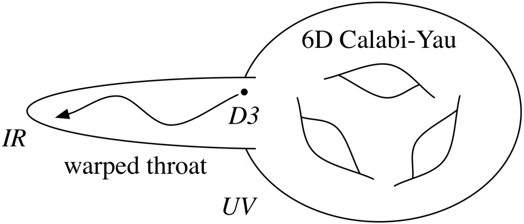
Detecting cosmic strings

- Lensing
- The CMB
- Gravitational radiation...

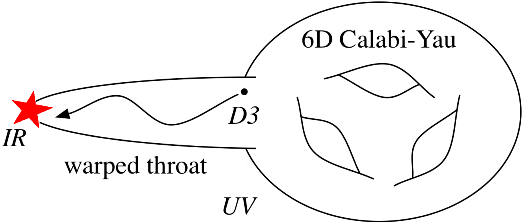


Closed loops give off a particularly distinctive gravitational wave signal. [Damour and Vilenkin 2001]

Extra dimensions and brane inflation



Cosmic strings at the tip?



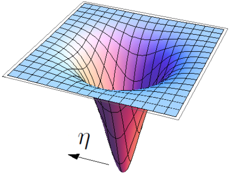
- Friction is required to stabilize strings at the tip.
- Model strings classically- relevant for the low energies of the current universe.

Warped metric

We use the Klebanov Strassler metric as an explicit solution for ds_6^2 and $h(\eta)$ - the warped, deformed conifold.

$$ds^2 = h^{-\frac{1}{2}}(\eta)\left(dt^2 - a(t)^2 d\mathbf{x}^2\right) - h^{\frac{1}{2}}(\eta) ds_6^2$$

η is a radial coordinate in the internal space.



For simplicity, look at motion in only one of the angular directions of the conifold, ϕ.

Modelling cosmic string motion

We model the string classically using the Nambu action.

$$S = -\mu \int d\tau d\sigma \sqrt{-\gamma}$$

This gives equations of motion to solve: PDEs in τ and σ.

$$\frac{\partial}{\partial t}\left(\frac{\dot{x}^a x'^2}{\sqrt{-\gamma}}\right) + \frac{\partial}{\partial \sigma}\left(\frac{x'^a \dot{x}^2}{\sqrt{-\gamma}}\right) + \frac{1}{\sqrt{-\gamma}}\Gamma^a_{bc}\left(x'^2 \dot{x}^b \dot{x}^c + \dot{x}^2 x'^b x'^c\right) = 0$$

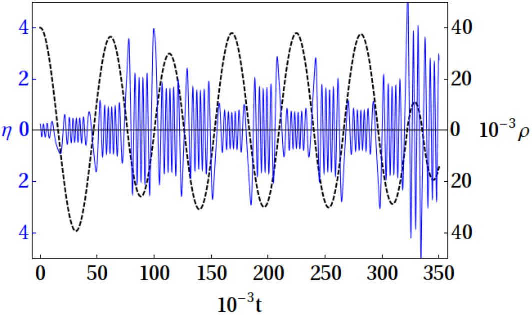
Sarah Chadburn
Durham University
Work with Ruth Gregory & Tasos Avgoustidis

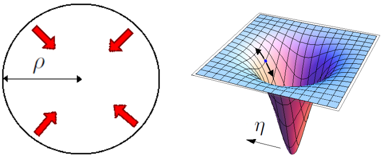
Studying the equations of motion

1. Look at conserved quantities. We see how energy could be transferred between different terms.

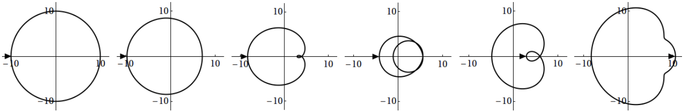
$$E = \sqrt{\frac{\mathbf{x}'^2 + h\epsilon^{\frac{4}{3}}\left(\frac{\eta'^2}{6K^2} + B\phi'^2\right)}{h\left(1 - \dot{\mathbf{x}}^2 - h\epsilon^{\frac{4}{3}}\left(\frac{\dot{\eta}^2}{6K^2} + B\dot{\phi}^2\right)\right)}}$$

2. Look at explicit trajectories to see that this transfer of energy really occurs.





3. Look at more complicated trajectories- numerical solutions to the full PDEs.



The same behaviour patterns show up, along with other interesting differences from the flat space case.

Investigating the system further

We've considered other factors such as:

- Additional fields associated with the Klebanov-Strassler solution.
- Loss of energy from the strings via gravitational radiation.
- The effect of the expansion of space.

Our conclusion that extra dimensional motion is likely to be significant holds true in every case.