The Colliding Bubble Braneworld Scenario

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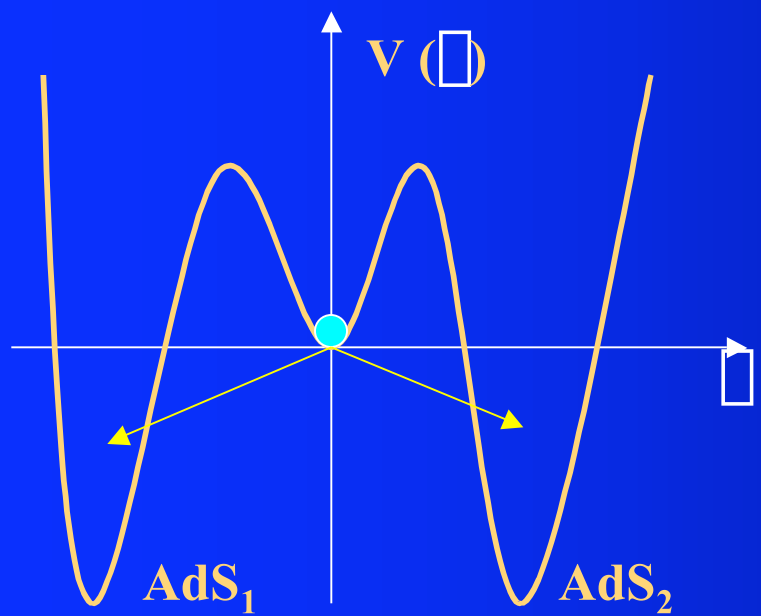
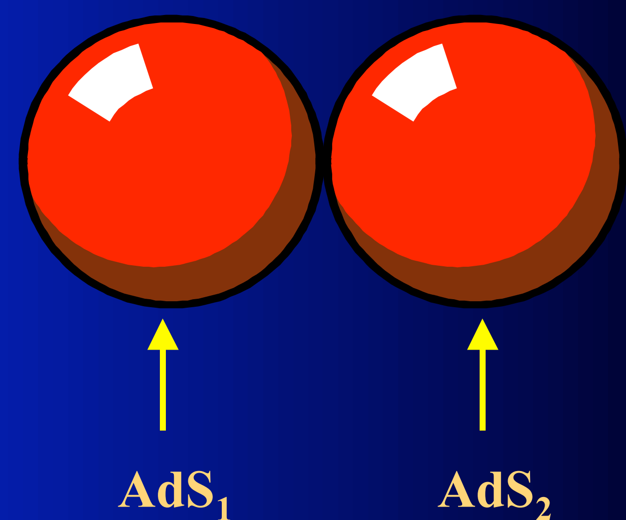
The Colliding Bubble Braneworld Scenario

(Bucher, 2001)

- Let us assume we have a scalar field □ living in a metastable state in Minkowski^5 or de Sitter^5 with a potential of the form:

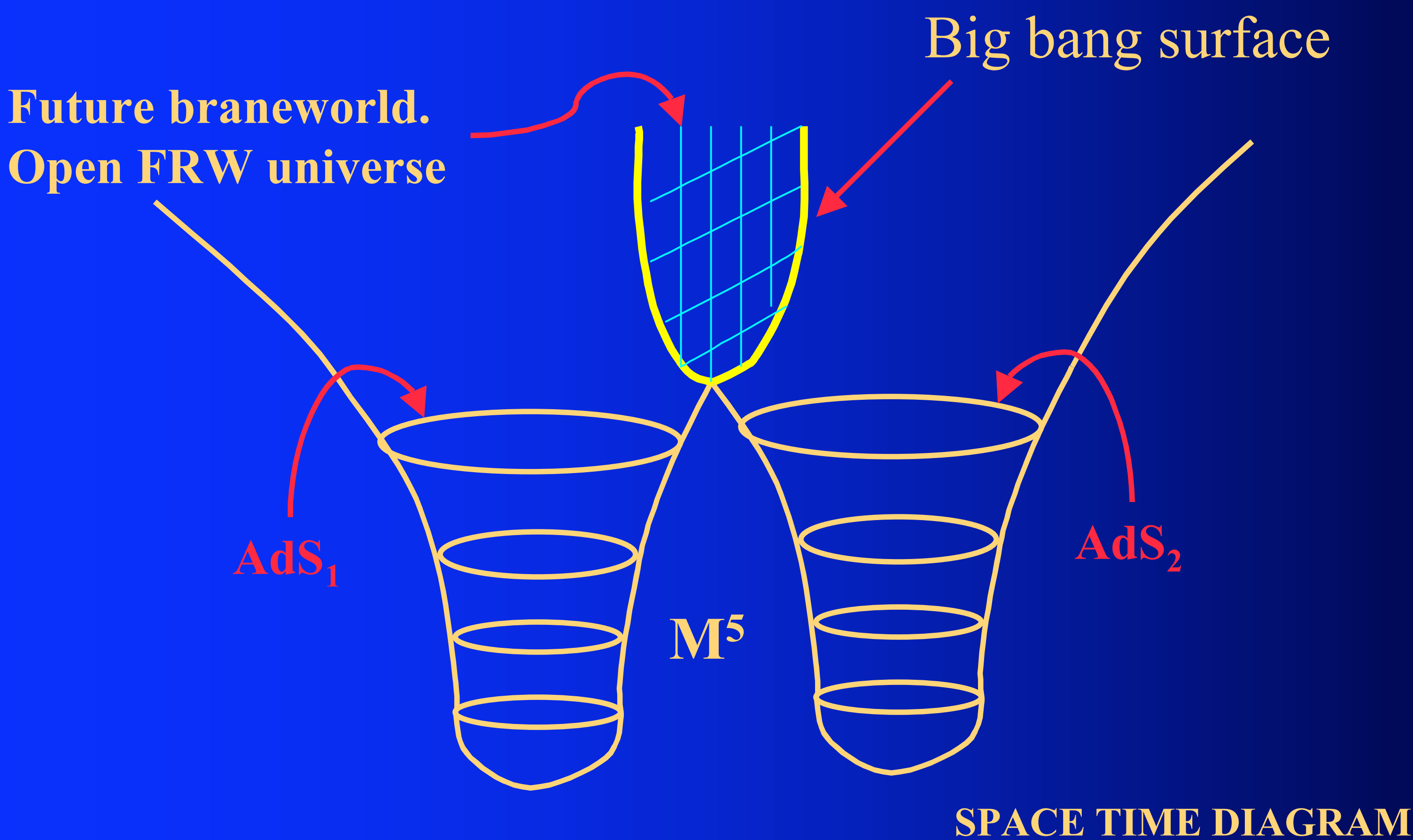


- The field can tunnel to the true vacuum with □<0 by forming a bubble filled with Anti-de Sitter spacetime. At each point this could happen to any of the two degenerate true vacuum.



Braneworld Formation

- When the bubbles collide a brane (domain wall) forms interpolating between the two AdS spaces on both sides of the wall. This is the brane where we live in:



Important points of the model:

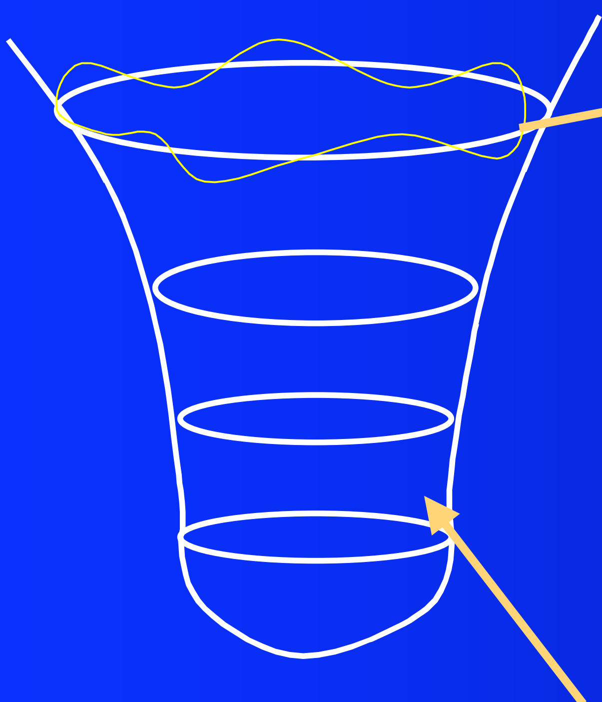
- The homogeneity and isotropy is provided by the symmetry of the tunneling process.
- The flatness problem is solved in this model if the bubbles nucleate at a large distance.
- We assume the energy of the collision is transferred into radiation of the brane.
- The braneworld formed in the future of the surface of collision is identical to a Randall-Sundrum universe.

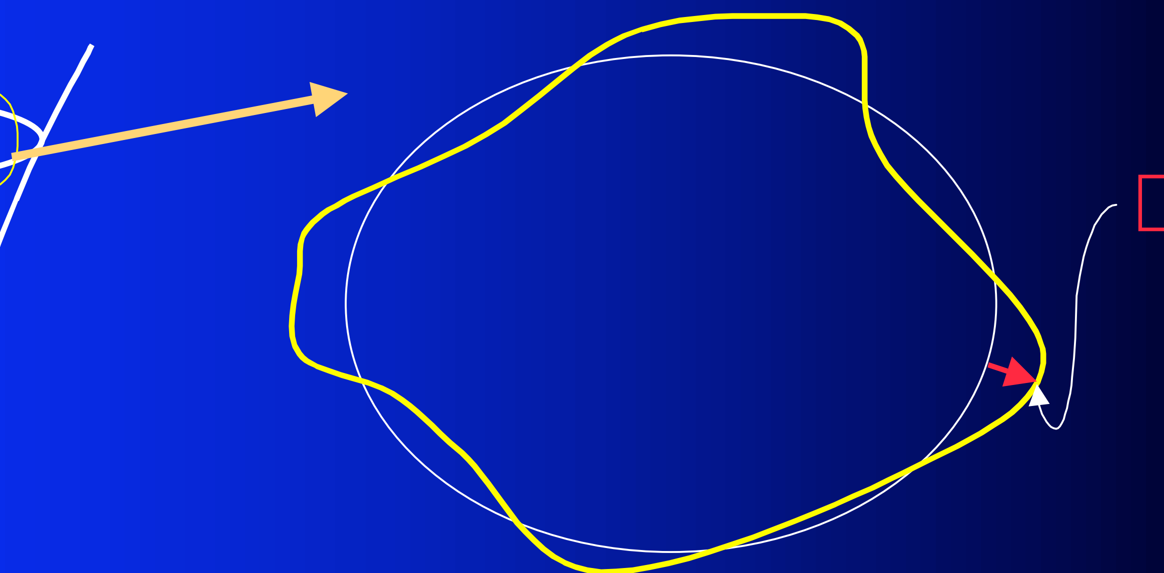
Cosmological Perturbations

(Blanco-Pillado and Bucher, 2002)

(Garriga and Tanaka, 2002)

- The homogeneous picture is modified by quantum fluctuations on the bubble worldsheet position.

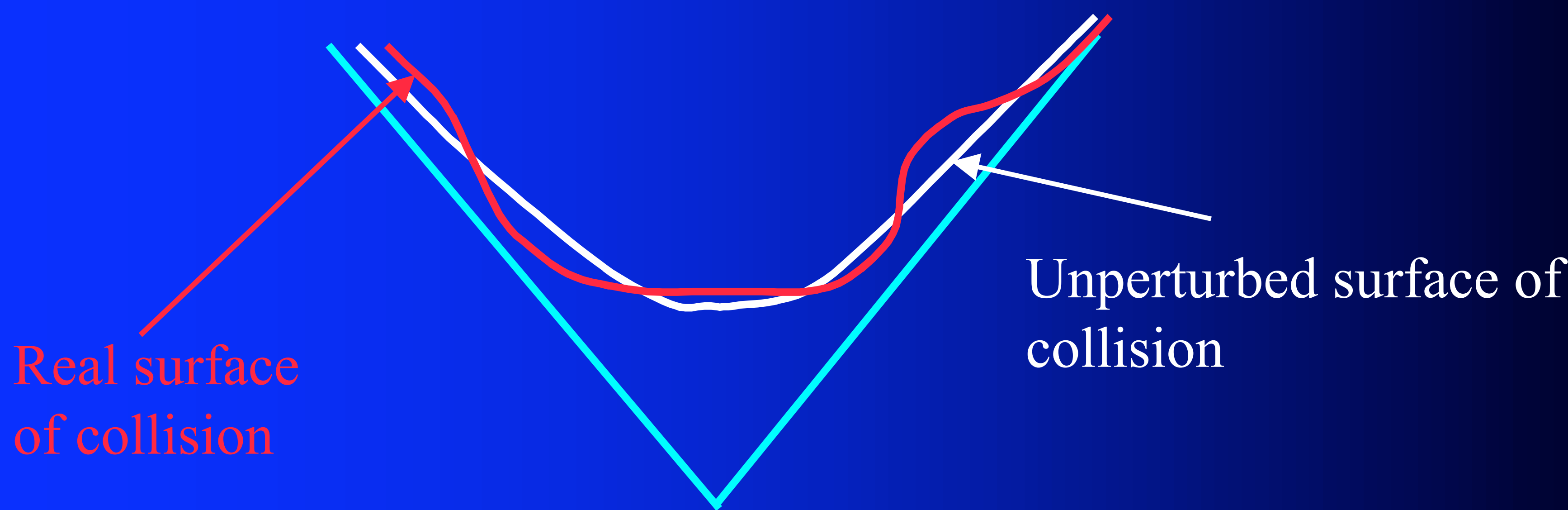




The fluctuations describing the distance of the real surface from the unperturbed one can be treated as a scalar field □ living on the bubble worldsheet, ie the 3+1 de Sitter spacetime (Garriga and Vilenkin, 92).

Cosmological Perturbations

- The perturbations on the bubbles leave their imprint on the surface of collision which becomes warped and with variable energy density.



Results

$$\left(\frac{\delta T}{T}\right)^2 \sim \left(\frac{R_0}{d}\right)^2 \sim \left(\frac{\text{Initial radius of bubble}}{\text{Distance between bubbles}}\right)^2 x \begin{cases} k^2 & \text{in } \mathbf{M}^5 \\ k^{-2} & \text{in } dS^5 \end{cases}$$

In order to solve the flatness problem we should have that:

$$\left(\frac{R_0}{d}\right) <<< 1$$

Therefore, even though the spectrum of perturbations from the fluctuations on the bubble walls is not scale invariant, it has a really tiny amplitude on cosmological scales.

Conclusions and future work

- The colliding bubble model provides a scenario for the formation of an open FRW universe a la Randall-Sundrum.
- It solves the flatness and homogeneity problems by its construction.
- However, the minimal model of perturbations generated by quantum fluctuations on the bubbles, have a very small amplitude and also a tilted spectrum in contradiction with observation.
- Future work includes:
  - Numerical evolution of the colliding bubbles including gravity in order to study the possible appearance of singularities in the bubble interior and its consequences for the brane observers.
  - Also, we are investigating the effect that other fields living on the bubbles can have on the amplitude and spectral index of the fluctuations.