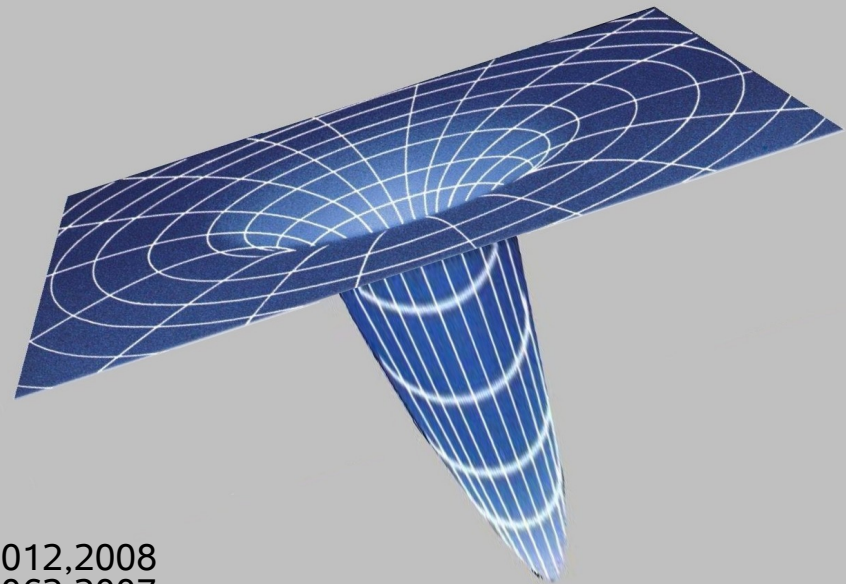# Gravitational effects upon topology changing transitions

Neil Butcher

14th May

UCL

Butcher, Saffin JHEP 0812:012,2008
Butcher, Saffin JHEP 0711:062,2007
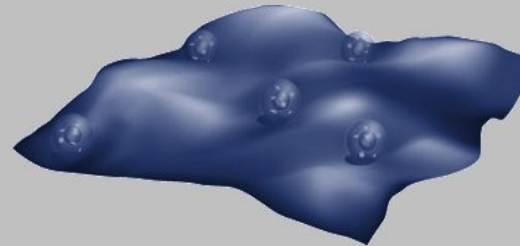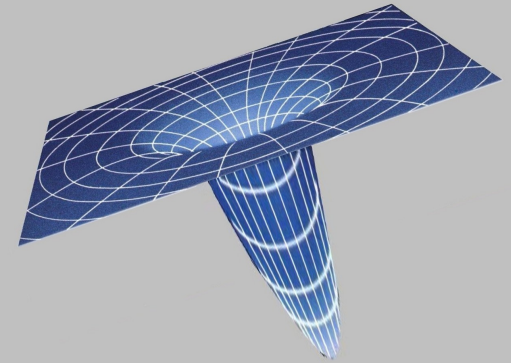
The University of
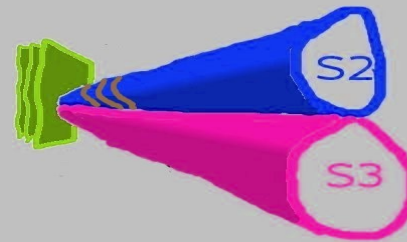Nottingham

Outline Of Things To Come

1) Background
- String vacua and landscape
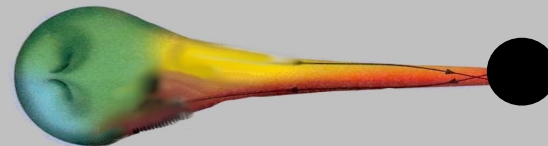- Topology changing transitions
- Gravitational difficulties
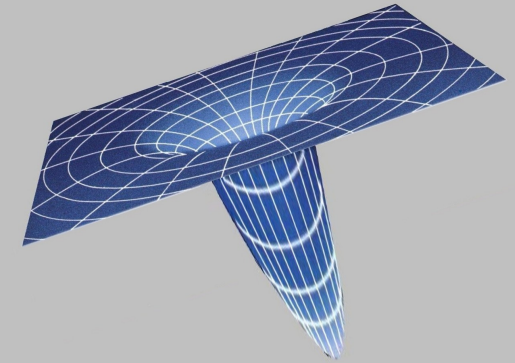
2) 7D Situations
- Motivation
- Results

3) Conclusions
- Effects on transitions
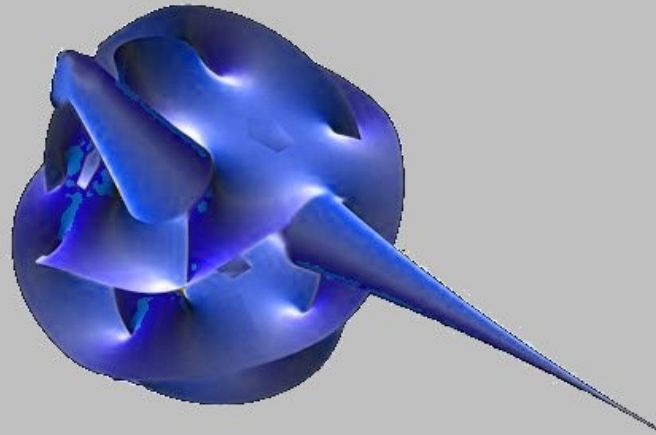- Consequences for existing models

Singular Manifolds

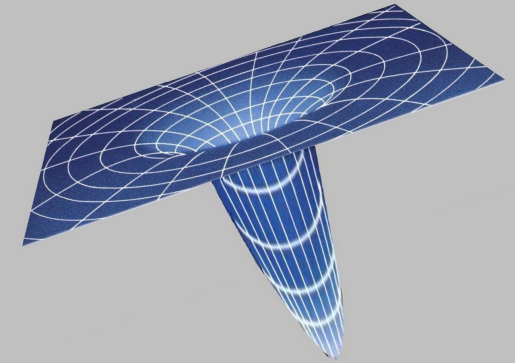Have a singular point, a conical singularity

They are not smooth and don't have one defined topology

They aren't Calabi Yau manifolds due to the singular point

They may be the limiting case of 2 different Calabi Yau
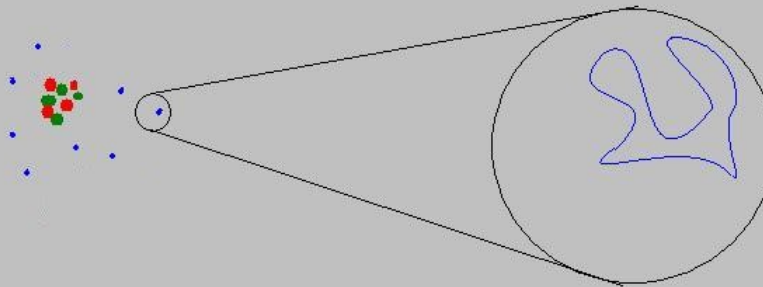   manifolds.

String Theory

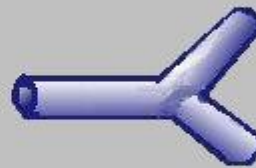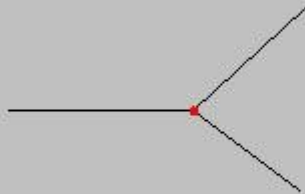String theory is a potential theory of quantum gravity
What we think of as point particles are in fact strings, very short strings
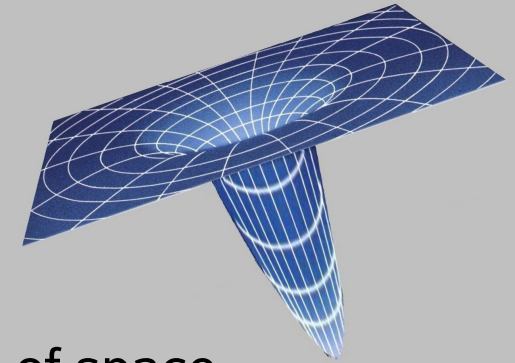
An atom with it's electrons

The Electron

Magnified

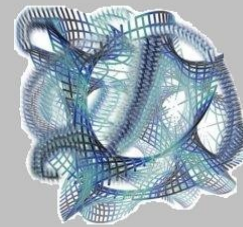Interactions do not occur at points but over areas.

Particle and String Interactions

String Vacua

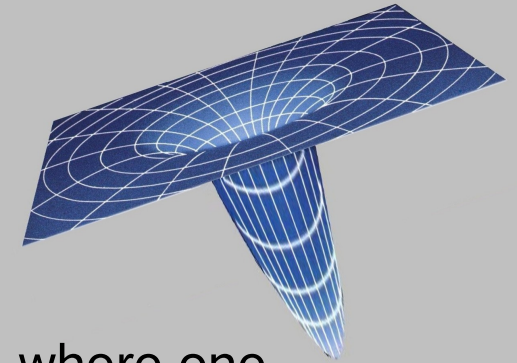Superstring theory requires 6 additional dimensions of space

They may be wrapped up as a
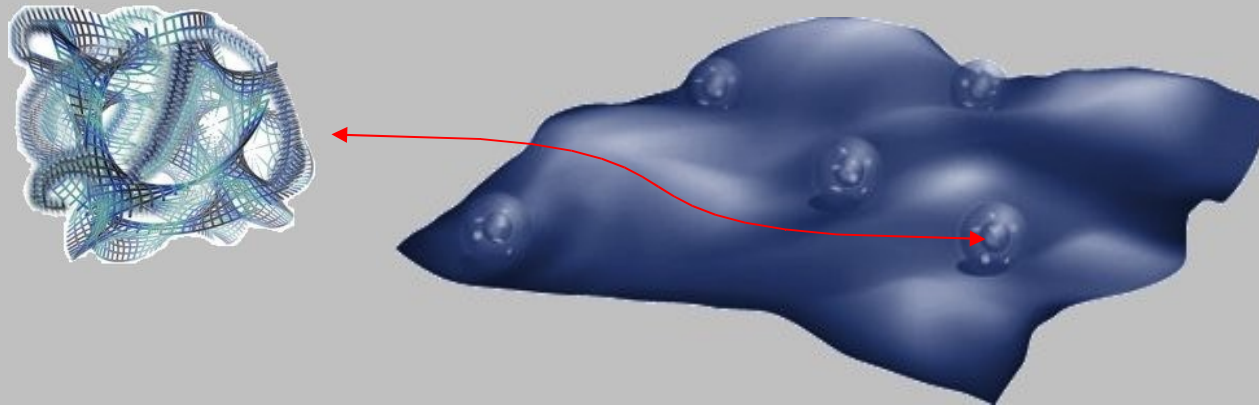"Calabi Yau" manifold.

These come in many topologies and each topology has many
   parameters.

The parameters form a parameter space, the range of all values the
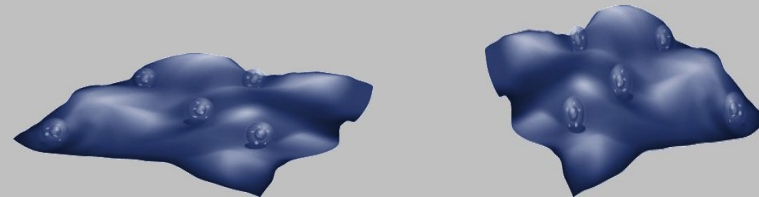   parameters can take.
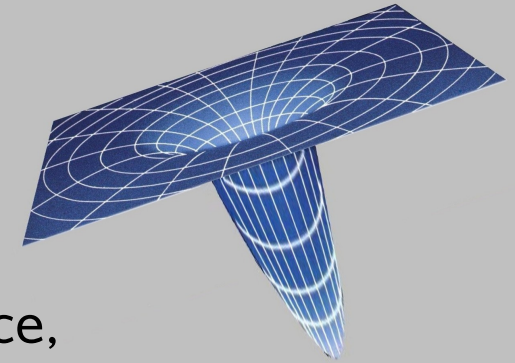
String Landscape

We can draw the parameter space as a landscape, where one point corresponds to one string vacua

Due to the differing topologies, the string landscape may consist of disconnected regions.
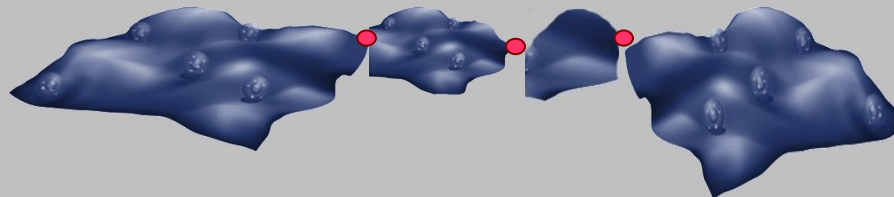
Unification of the Landscape

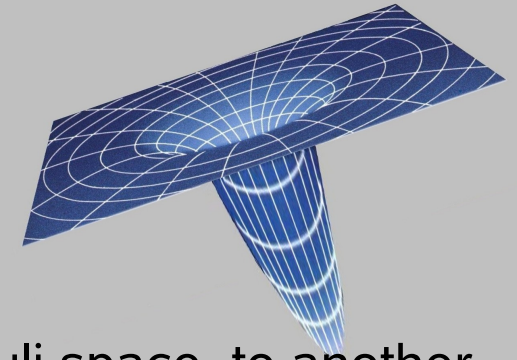Singular manifolds exist as limits of the moduli space,

One singular manifold can be the limit of 2 different topologies landscape.
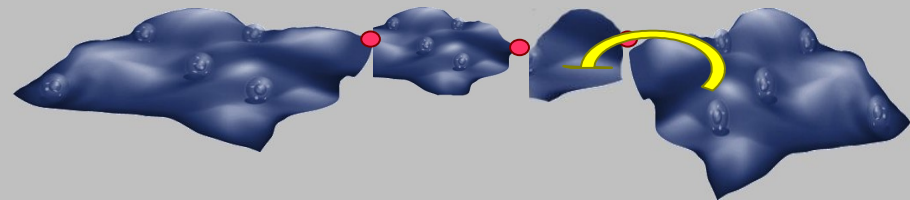
With multiple links we can join all moduli spaces.

The Hope Of Transitions

There's the possibility of a transition from one moduli space to another, through the singular manifold.

This could change the topology of the manifold.

Transitions

The Hope Of Transitions

There's the possibility of a transition from one moduli space to another, through the singular manifold.
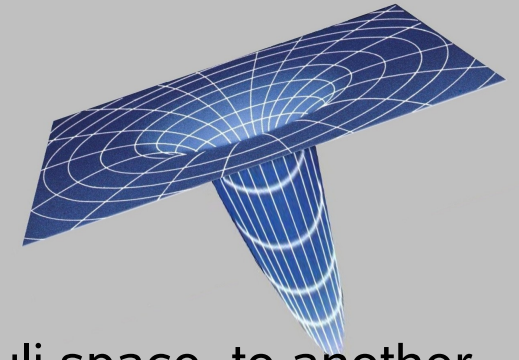

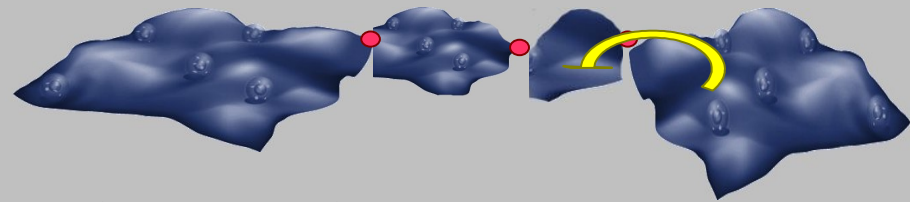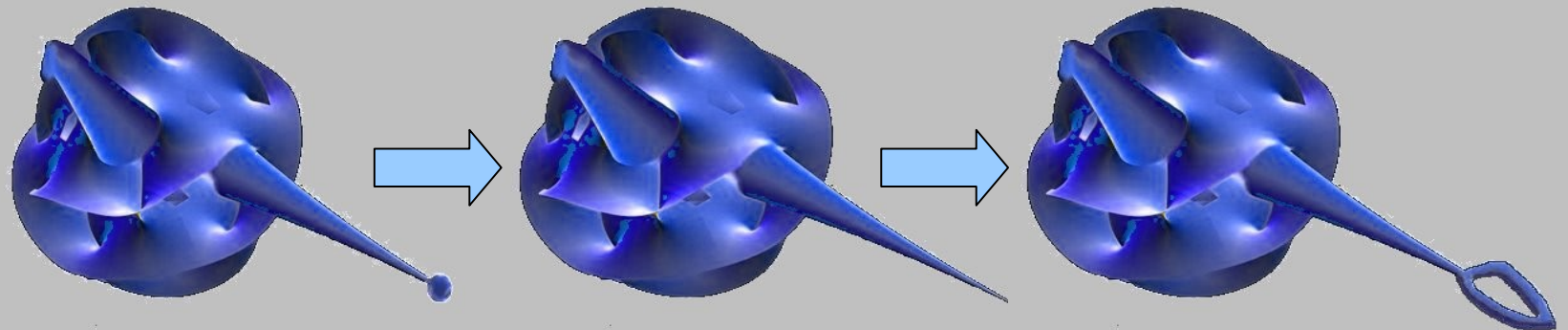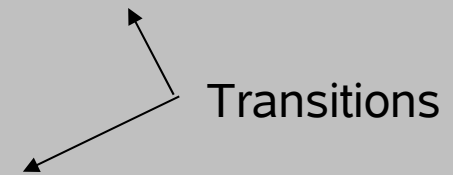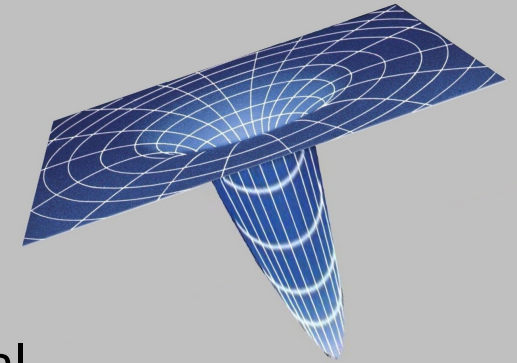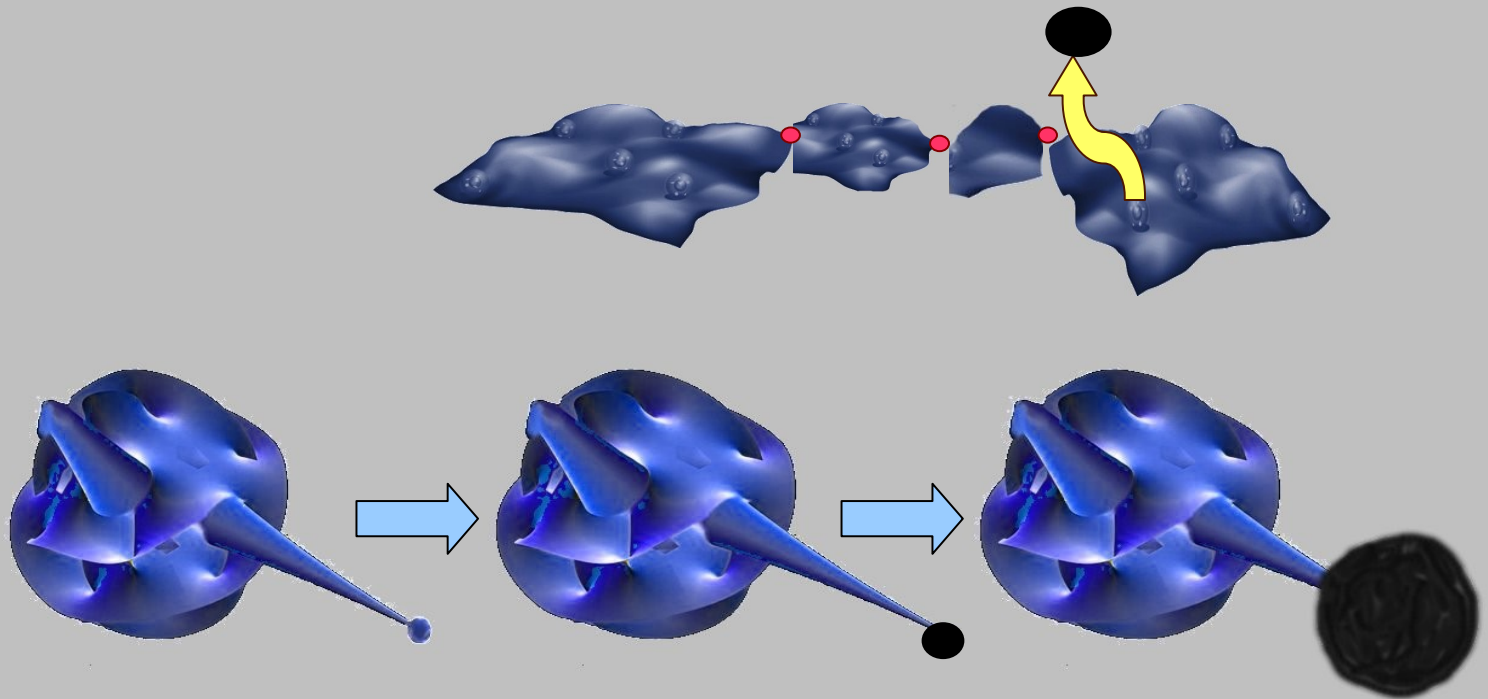This could change the topology of the manifold.

Transitions

The Danger of Gravity

The transition may be prevented by the gravitational formation of a black hole, instead of the transition we intended. We would leave the string landscape altogether

Seven Dimensional Collapse
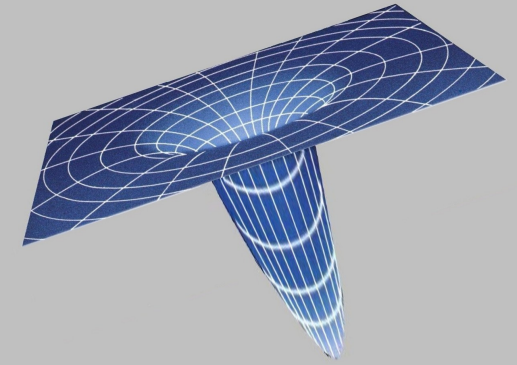
Seven dimensional simulations are applicable to
   string theories.

The Calabi-Yau manifolds of the string landscape have six dimensions
   of space.

Introducing time also requires a seven dimensional simulation

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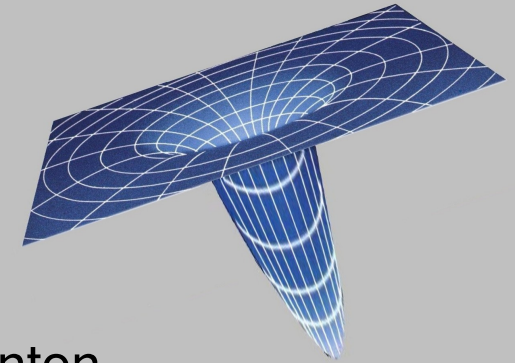
The Conifold

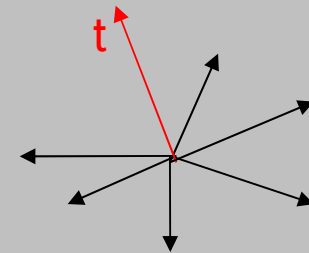The conifold is a six dimensional gravitational instanton with a conical singulatity at its tip.

$$ds^2 = dr^2 + r^2 \, ds^2_{base}$$

Where the base is called T_{11} and has the topology S2 x S3.

Branes on Conifolds

One use of the conifold solution is to use it as a
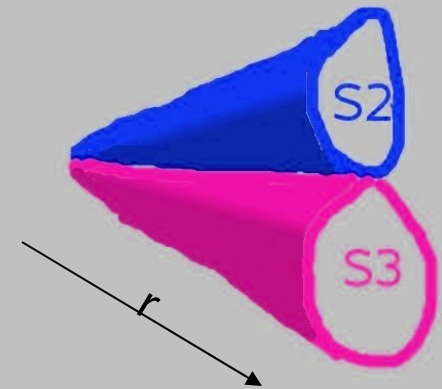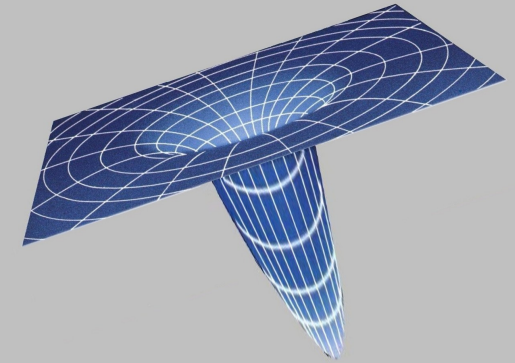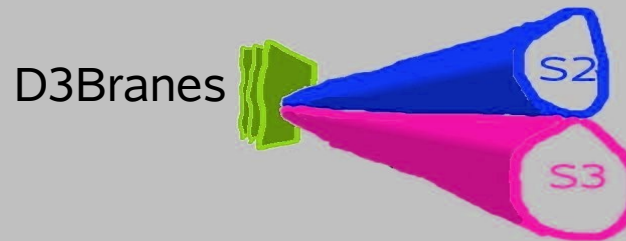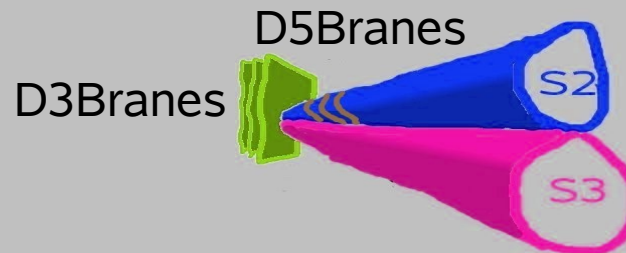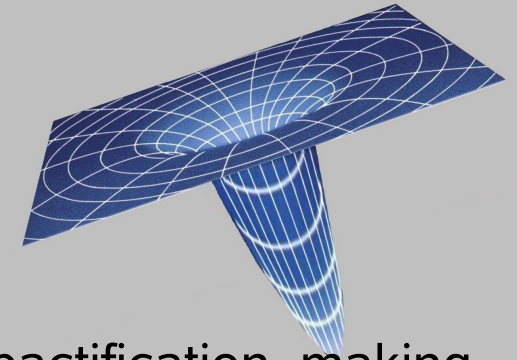   background for a stack of D3 branes, leading to AdS/CFT dualities
   with N=1 supersymmetry.

D3Branes

Adding wrapped D5-branes at the apex produces a confining gauge
   theory (at the IR scale) whose duals are warped deformed conifolds.

D5Branes

D3Branes

Uses of Conifolds

The conifold can be embedded within a string compactification, making a smooth throat part of a Calabi-Yau manifold.
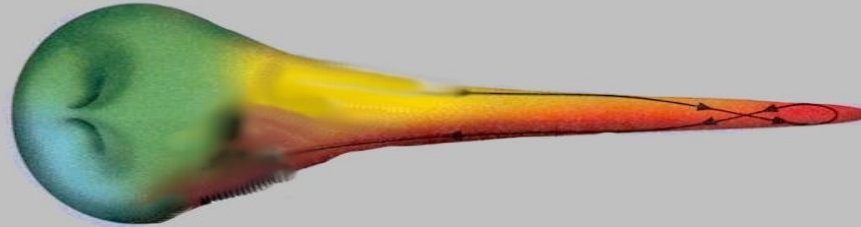
It can be possible to create slow roll inflation and, with tuning, "branes" may approach the tip and then turn back.

The throat is often taken to be static, no back reaction which may change or collapse the throat is considered.

The Smoothed Conifold

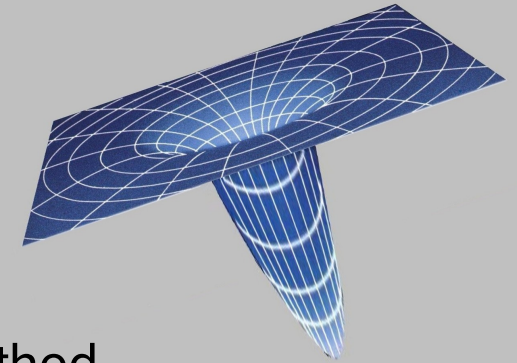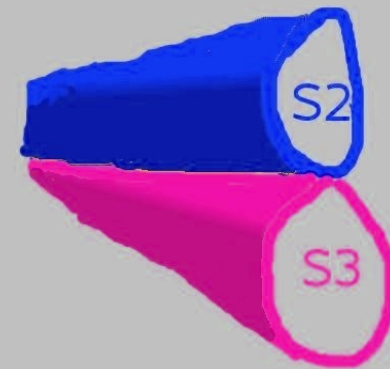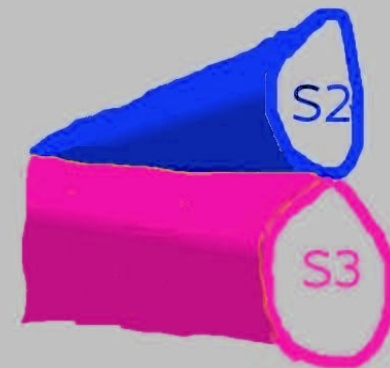The conical singularity of the conifold can be smoothed out in two distinct ways.

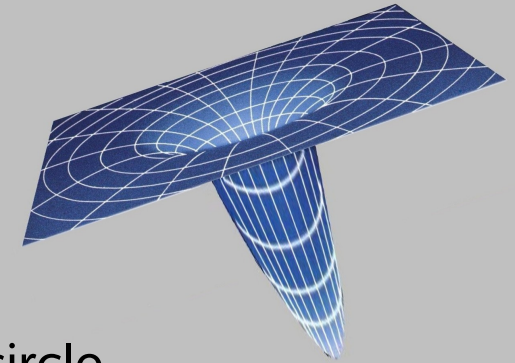The Resolved Conifold has an extended S2 at its tip, this has smoothed the manifold

The Deformed Conifold expands the origin of the conifold into an S3 to rectify the singularity
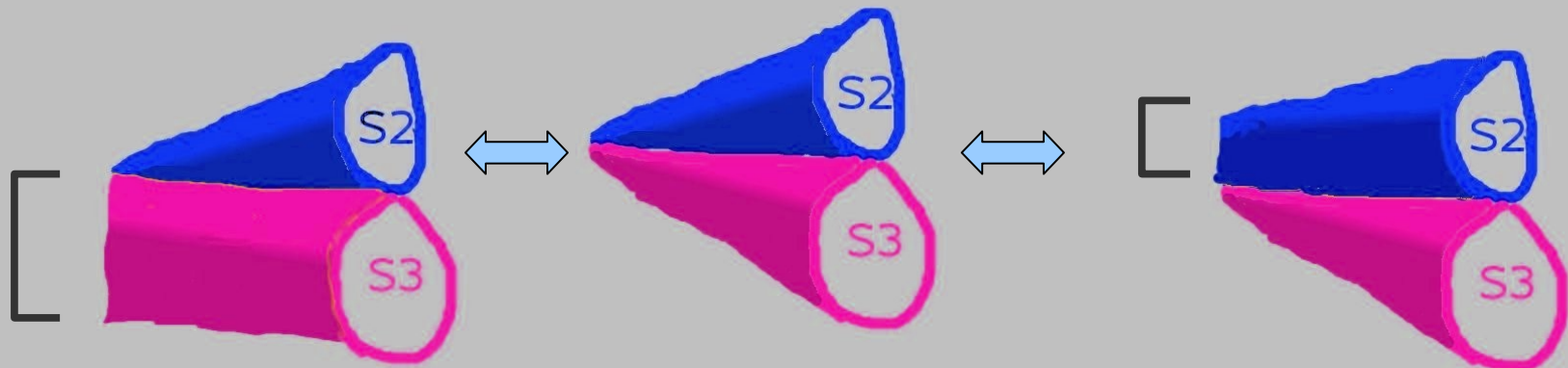
Conifold Transitions

We would shrink a 3d sphere and re-expand a 2d circle.

It would be a more drastic transition.

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Conifold Transition Findings
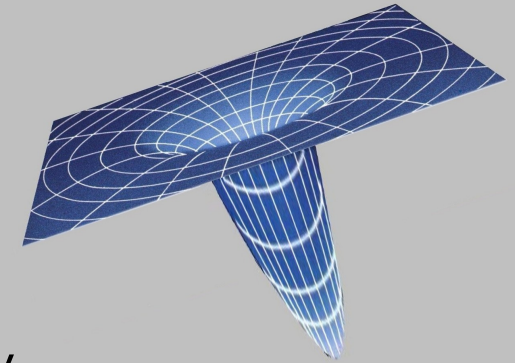
It seems that a space-time with a conical singularity
(the conifold) can't be created dynamically from a smoothed
manifold.

Collapsing the circles at the tip always created black hole event
horizons.

Butcher, Saffin JHEP 0812:012,2008

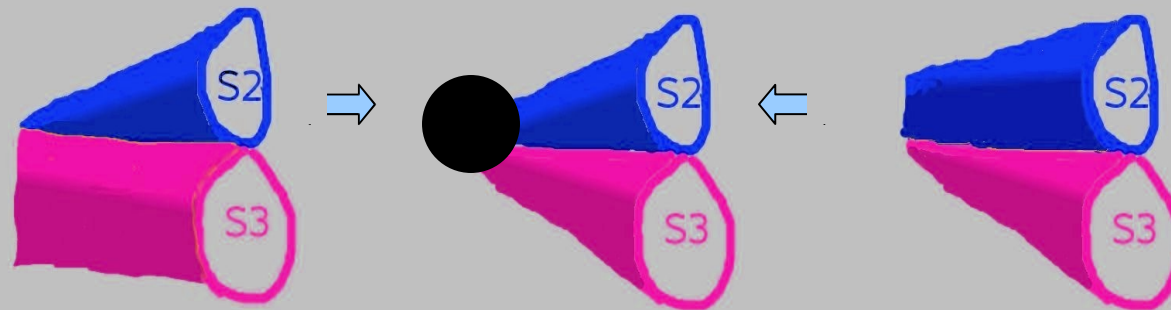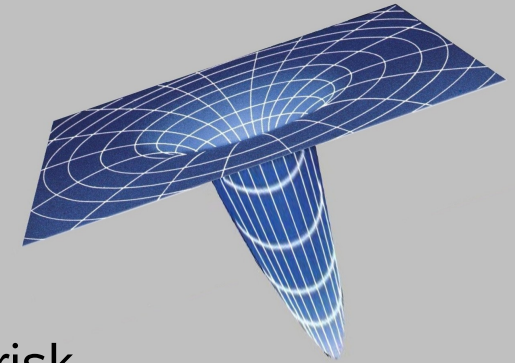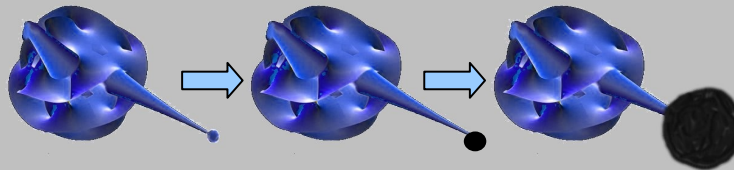# Consequences

The creation of black hole horizons is a very great risk

gravitational collapse cannot be overlooked. This collapse will prevent the topology transition by masking the effects behind the horizon.
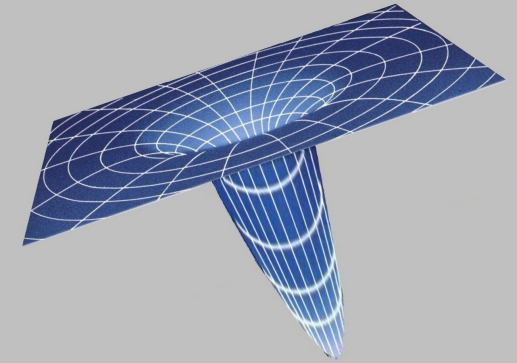

The black hole makes some other theories inapplicable.

If the same is true of other tight throats, then the common approximation that the throat is static is not valid.
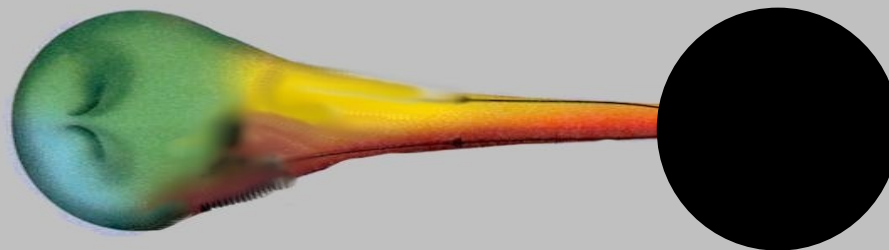
Summary

Transitions may offer a way to unite the string landscape.

They require non-singular manifolds to become singular dynamically, however inciting this may cause black holes to form.

Numerical simulation is showing that black holes do form, previous results coming from studying the low energy dynamics of moduli fields are inapplicable.

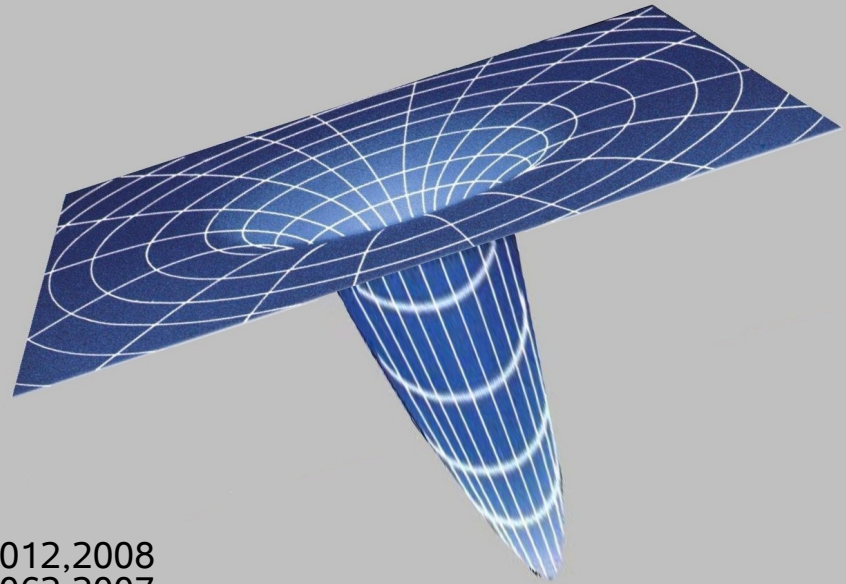This reduces the hope that transitions may dynamically change the topology.

Other approaches such as inflation models which require the use of tight "throats" must also account for back reactions which may collapse the throat.

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