

The New York Times

## Before the Big Bang, There Was . . . What?

### Inflationary Bubbles and Other Ideas

To explain what might have existed before the birth of the universe, cosmologists turn to a number of imaginative theories.

#### CURRENT THEORIES

##### QUANTUM UNCERTAINTY

On the tiny, quantum scale, particles exist only as clouds of probability until they are actually observed.

OBSERVER



ATOM  
NUCLEUS

CLOUD OF ALL POSSIBLE  
POSITIONS OF THE ATOM'S  
ELECTRONS

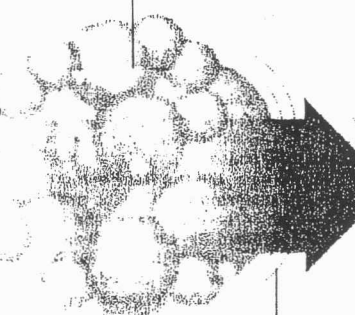
Sources: "Cosmology for  
Beginners," by John Gribbin;  
Scientific American

The New York Times/Photograph by NASA (universe)

By DENNIS OVERBYE

##### QUANTUM FLUCTUATIONS

Particles can also flit in and out of existence in a kind of "foam," even in empty space. A tiny universe could have appeared seemingly out of nothing.

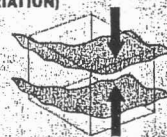


##### ENERGY FIELDS

Certain kinds of energy fields could have temporarily imbued space with negative gravity, blowing the early universe apart.

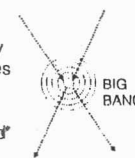
##### BRANE THEORY (STRING THEORY VARIATION)

In this cosmology, three-dimensional islands, or membranes, float in a five-dimensional megaverse. If two membranes were to collide, the clash could ignite a Big Bang.



##### STRING THEORY

In this cosmology, the universe consists of tiny loops of vibrating strings that form the particles of ordinary matter. According to string theorists, the Big Bang may be a transition from a previously shrinking universe that has reached its minimum size and started to expand.



##### INFLATION

##### INFLATION THEORY

A furious expansion stretches the fabric of space, taking it from the size of a proton to the size of a grapefruit in a tiny fraction of a second.

##### BIG BANG

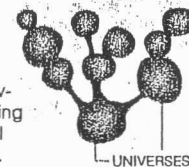
The energy of inflation becomes a hot fireball that continues growing into a dense soup of matter.

##### THE UNIVERSE

The fireball eventually cools and expands into our universe.

##### ETERNAL INFLATION

The inflationary bubble that gave rise to the universe could occur many times with each universe giving rise to the next in a never-ending tree of universes with the potential for different physical laws in each.



##### QUANTUM COSMOLOGY

Just as a particle exists as a cloud of probability, theoretically everywhere at once until it is observed, some theorists suggest that our universe encompasses all possibilities until it is observed to have a particular set of physical rules.