

# Superstring Theory

**Superstring theory** is an attempt to explain all of the particles and fundamental forces of nature in one theory by modeling them as vibrations of tiny supersymmetric strings. It is considered one of the most promising candidate theories of quantum gravity. Superstring theory is a shorthand for "supersymmetric string theory" because unlike bosonic string theory, it is the version of string theory that incorporates fermions and supersymmetry.



The basic idea is that the fundamental constituents of reality are strings of the Planck length (about  $10^{-33}$  cm) which vibrate at resonant frequencies. The graviton (the proposed messenger particle of the gravitational force), for example, is predicted by the theory to be a string with wave amplitude zero. Another key insight provided by the theory is that no measurable differences can be detected between strings that wrap around dimensions smaller than themselves and those that move along larger dimensions (i.e., effects in a dimension of size  $R$  equal those whose size is  $1/R$ ). Singularities are avoided because the observed consequences of "big crunches" never reach zero size. In fact, should the universe begin a "big crunch" sort of process, string theory dictates that the universe could never be smaller than the size of a string, at which point it would actually begin expanding.

## Number of dimensions

Our physical space is observed to have only four large dimensions, and a physical theory must take this into account. But nothing prevents one from having more than 4 dimensions per se. In the case of string theory, consistency requires spacetime to have 10, 11 or 26 dimensions. The conflict between observation and theory is resolved by making the unobserved dimensions compact dimensions.



## Number of superstring theories

Theoretical physicists were troubled by the existence of five separate superstring theories. This has been solved by the second superstring revolution in the 1990s during which the five superstring theories were discovered to be different limits of a single underlying theory. See M-theory.

**M-theory** is a solution proposed for the unknown theory of everything which would combine all five superstring theories and 11-dimensional supergravity together. According to Dr. Edward Witten, who proposed the theory, mathematical tools which have yet to be invented are needed in order to fully understand it.

