

Duality among String Theories

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In the 80s, it was realized that spacetime needs to be ten-dimensional if the elementary particle is in fact made of relativistic strings. What puzzled theorists in those days was that, in fact, there are five consistent string theories, called Type IIA, Type IIB, Type I, Heterotic $E_8 \times E_8$, and Heterotic $SO(32)$. A few years later, people recognized that two Type II theories are the same theory if they are put on a small circle, and that two heterotic theories become similarly the same on a circle. These relations are called T-dualities. In the 90s, the S-duality relating Type I theory and Heterotic $SO(32)$ theory was appreciated. Also, the existence of an 11-dimensional theory whose basic excitations are membranes is realized. This theory, called the M-theory, becomes Type IIA string or Heterotic $E_8 \times E_8$ theory if it is put on a small circle or on a small segment, respectively. Thus, all five string theories turned out to be in fact a single physical system. This is now the foundation of string theory research.

