

1. IIB from M-theory

Consider M-theory compactified on a T^2 characterized by radii R_9 and R_{10} . Regarding R_9 as the 11th dimension takes you to type IIA with string coupling g_A compactified on a circle of radius R_A . Performing T-duality on the IIA circle takes you to IIB with coupling g_B on a circle of radius R_B .

- (i) Express g_A , R_A , g_B , R_B as well as the string length ℓ_S in terms of the M-theory quantities R_9 , R_{10} , ℓ_{11} .
- (ii) Working backwards along the chain of dualities, what is the M-theory origin of the following objects in IIB?
 - a fundamental IIB string with no winding or momentum on the circle, but extended in a non-compact direction?
 - a fundamental IIB string with w units of winding on the circle?
 - a massless mode of the fundamental IIB string with n units of momentum on the circle?
 - a D1-brane with no winding or momentum on the circle, but extended in a non-compact direction?
 - a D1-brane wound on the circle?
 - a D3-brane extended in three non-compact directions?
 - a D3-brane wrapped around the circle and extended in two non-compact directions?
- (iii) Check that the energies / tensions of all the M-theory objects you constructed match the IIB expectations.
- (iv) What does S -duality in type IIB correspond to in the M-theory picture?
- (v) Show how the M-theory objects you constructed fit together into S -duality multiplets.