UNIVERSITY OF CAMBRIDGE

MATHEMATICAL TRIPOS Part III

Thursday 6 June 2002 1.30 to 4.30

# PAPER 67

# STRING THEORY

*Attempt **FOUR** questions*

*There are **five** questions in total*

*The questions carry equal weight*

**You may not start to read the questions printed on the subsequent pages until instructed to do so by the Invigilator.**

**1** Derive the classical equations of motion for the relativistic string from the Nambu-Goto action. Show that there are motions in which the string is a straight line at any instant of time. Derive the relation between mass and angular momentum for these motions.

**2** Explain the role of the Virasoro algebra in the covariant quantization of the Nambu-Goto action, deriving expressions for the generators of the algebra. Explain the signficance of the No Ghost Theorem for the structure of the physical states. [It is not necessary to give a proof of the theorem.]

**3** Why are ghost fields introduced in the quantization of the Polyakov action for the string? Outline the relevance of BRST symmetry and how it operates in string theory.

**4** Describe the effect on the spectrum of a closed (bosonic) string of compactifying one of the dimensions of space into a circle of radius $R$. Describe the relationship between the spectra for large $R$ and for small $R$ and show how that at a particular value of $R$ there are more massless spin 1 particles.

**5** Outline the introduction of fermionic fields into string theory, explaining the difference between the Ramond and Neveu-Schwarz sectors. Discuss the space-time characteristics of the various sectors in open and closed string theories and the nature of the lowest states in these sectors. Explain the effect of the GSO projection.