

Punctures on Super Riemann Surfaces

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Received March 26, 1991

Abstract. An investigation of the geometry of punctured super Riemann surfaces and their moduli is pursued with particular emphasis on Ramond (or spin) punctures. A central role is played by the notion of a standard punctured neighborhood, which may be glued into a super Riemann surface to create a punctured surface. A geometrical explanation is given for the rule that two Ramond punctures only have one odd modulus. Explicit examples of spheres with Ramond and Neveu–Schwarz punctures are constructed and the connection between moduli of punctures and picture changing is elaborated. This description of punctures combined with the operator formalism should be useful both in treating fermionic or (R, R) sector backgrounds for the superstring and in the unitarity proof for the superstring.

Much progress has been made on derivation of superstring amplitudes and elucidation of their properties in the Ramond–Neveu–Schwarz formulation. In this development a central role has been played by the supergeometry of super Riemann surfaces (SRSs) and their supermoduli spaces¹. Goals in this development include proofs of the unitarity [3] and finiteness of the superstring (or heterotic string). A second set of goals is a better understanding of the general structure of string amplitudes, in particular with an eye towards understanding the basic variables in which string theory should be formulated and towards discovering the fundamental symmetries of string theory. Particularly promising in this direction has been the development of the operator formalism [4–6] which systematizes the derivation of string amplitudes, taking into account the many subtleties that have arisen, and may go beyond to point the way to a more fundamental formulation of string theory. The construction of the operator formalism for the superstring has in particular relied on aspects of the mathematics of SRSs.

Despite significant success in the treatment of superstring amplitudes, open issues remain. Some of these center on the proper inclusion of vertex operators,

* On leave from the Harvard Society of Fellows. Supported in part by D.O.E. Outstanding Junior Investigator Grant DE-AT03-76ER70023

¹ For reviews see [1, 2]