

ABSTRACT

The AdS/CFT correspondence stands as one of the most profound achievements in modern theoretical physics, providing an equivalence between gauge and gravity theories. In its best understood realisation, it relates Type IIB superstring theory on $AdS_5 \times S^5$ to $\mathcal{N} = 4$ super Yang-Mills theory in four dimensions. A central obstacle in establishing this duality in full generality is the *spectral problem*, namely the exact matching of the string energy spectrum with the spectrum of anomalous dimensions in the dual gauge theory. Two key breakthroughs in addressing this challenge have been the development of semiclassical methods for string quantisation and the discovery of rich underlying integrable structures on both sides of the correspondence.

Motivated by these advances, and by the ongoing efforts to extend gauge/gravity duality beyond the AdS paradigm, this thesis investigates classical string dynamics in a variety of brane-induced, deformed, and non-relativistic backgrounds. We focus on non-trivial string configurations such as pulsating and rotating strings, which serve as sensitive probes of the underlying geometry and symmetry structure. The primary aim is to elucidate how these exotic configurations encode dynamical information of the dual gauge theory through energy-oscillation number and energy-spin dispersion relations, in both relativistic and non-relativistic limits. An additional objective is to identify and exploit the integrable structures governing the string dynamics, notably Neumann-Rosochatius-type models.

We study pulsating string solutions in the near-horizon region of NS5-branes and intersecting NS5-brane backgrounds, and compute their dispersion relations in the semiclassical and short-string limits. We then extend this analysis by constructing a Neumann-Rosochatius-type integrable model in the near-horizon geometry of intersecting NS5-branes (so called I-brane background) in the presence of mixed flux, and study the system using the Neumann method. Subsequently, we investigate the stability of pulsating string configurations in the χ -deformed $AdS_3 \times S^3$ geometry under normal perturbations. Finally, the thesis is devoted to extending the analysis of pulsating and spinning string solutions to the non-relativistic limit of the $\mathbb{R} \times S^2$ geometry.

Keywords: Classical strings, AdS/CFT correspondence, Semiclassical limit, Integrable model, Non-relativistic string