Contribution ID: **242** Type: **Poster**

Thermal Equilibrium in String Theory in the Hagedorn Phase

In string theory, a thermal state is described by compactifying Euclidean time on a thermal circle S^1_β, of fixed circumference. However, this circumference is a dynamical field which could vary in space, therefore thermal equilibrium is not guaranteed. We discuss a thermal state of type II string theory near and above the Hagedorn temperature and show that the circumference of the thermal circle can indeed be fixed and stabilized in the presence of a uniform isotropic flux.
We solve the equations of motion derived from an action that reproduces the tree-level string S-matrix. We find solutions with the topologies of $S^1_\beta \times S^2 \times calM^{d-2}$ at a fixed temperature, which include a space-filling winding-mode condensate and a uniform Neveu-Schwarz Neveu-Schwarz flux supported on $S^1_\beta \times S^2$. The solutions that we find have either a linear dilaton or a constant dilaton, in which case, we find solutions with either a cosmological constant or a Ramond-Ramond flux. We then compare our solutions to the cigar and cylinder backgrounds associated with the $SL(2,R)/U(1)$ coset theory, which include a winding-mode condensate but without flux. We also compare and contrast our solutions with the non-uniform Horowitz-Polchinski solution, which also possesses a winding-mode condensate and is characterized by an approximate thermal equilibrium near the Hagedorn temperature.

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Session Classification: Reception & Poster session