Contribution ID: **1145** Type: **Oral (Student, In Competition) / Orale (Étudiant(e), inscrit à la compétition)**

Reentrant phase transitions and van der Waals behaviour for hairy black holes

Tuesday 14 June 2016 09:45 (15 minutes)

The thermodynamics of black holes has remained a subject of interest for more than 40 years. Recently attention has been devoted to the thermodynamics of black holes in extended phase space where the cosmological constant is treated as a thermodynamic variable with the interpretation of pressure. Within this framework, Kubiznak and Mann demonstrated that the charged anti de Sitter black hole is thermodynamically analogous to the van der Waals fluid. A plethora of subsequent work deepened this connection, finding examples of van der Waals behaviour, triple points, and (multiple) reentrant phase transitions for AdS black holes. In my talk I will discuss recent work where we have applied this formalism for the first time to hairy AdS black holes by considering Einstein-Maxwell-AdS gravity conformally coupled to a scalar field in five dimensions. In the absence of electric charge we recover a van der Waals analogy for these black holes for particular configurations of the scalar field. More interesting behaviour is found in the charged case, where both van der Waals behaviour and reentrant phase transitions are seen to occur, the latter due to a modified Bekenstein-Hawking entropy of these black holes. These black holes have an interesting zero-entropy limit at which all critical behaviour ceases.

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Session Classification: T1-8 General Relaivity (DTP) / Relativité générale (DPT)

Track Classification: Theoretical Physics / Physique théorique (DTP-DPT)