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Magnetic charge effects on thermodynamic phase transition of modified anti de Sitter Ayón-Beato-García black holes with five parameters

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Abstract. In this paper, we choose a generalized Ayón-Beato-García (ABG) magnetic charged black hole with five parameters to investigate the possibility of thermodynamic phase transition and coexistence of different gas/liquid/solid phases of this black hole. In fact, this work is an extension of our recent work where ABG black hole with three parameters were used to seek the phase transition. In this work, we obtain other physical values on the parameters with respect to our previous work, where the phase transition happens together with the coexistence point of different phases in the phase space.

Keywords: Black Holes; Thermodynamics; Phase Transition; Magnetic Charge; Non Singularity.

1 Introduction

After that Ayón, Beato and García (ABG) [1] considered a nonlinear electromagnetic field to produce a nonsingular magnetic black hole which applies to modeling central black holes of galaxies. Other authors try to extend his model with more parameters [2–4]. For instance, Cai and Miao [5] take on a generalized ABG black hole solution which is dependent on five parameters named as the mass, the magnetic charge, and three dimensionless parameters, which are related to nonlinear electrodynamic fields. This kind of black hole returns to a regular black hole under special conditions. In the introduction of our previous work [6], we described applications of this type of the black hole more, and we studied its thermodynamics phase transitions but with some symmetries on parameters of this black hole. In this work, we like to be free of the restrictions on the parameters of the generalized ABG black hole, and we investigate its thermodynamic phase transition. In the black hole thermodynamics, to produce that equation of state in the usual way, we need a suitable pressure that is affect on the black hole by its environment. This is done by applying a negative cosmological parameter originating from anti de Sitter vacuum space. Fortunately, magnetic charge of this kind of black hole can produce a variable cosmological parameter itself, and there is no need to use an unknown cosmological constant similar to the well-known Schwarzschild de Sitter one. In this way, Hawking and Page discovered a first-order phase transition for black holes in anti de Sitter space-time [7]. Other types of phase transitions have been followed