Available online at www.sciencedirect.com

ScienceDirect

Nuclear Physics B 889 (2014) 109–119

NUCLEAR PHYSICS B

www.elsevier.com/locate/nuclphysb

Holographic entanglement entropy in metal/superconductor phase transition with Born–Infeld electrodynamics

Weiping Yao, Jiliang Jing *

Department of Physics, and Key Laboratory of Low Dimensional Quantum Structures and Quantum Control of Ministry of Education, Hunan Normal University, Changsha, Hunan 410081, People's Republic of China

Received 10 August 2014; accepted 6 October 2014

Available online 18 October 2014

Editor: Herman Verlinde

Abstract

We investigate the holographic entanglement entropy in the metal/superconductor phase transition for the Born–Infeld electrodynamics with full backreaction and note that the entropy is a good probe to study the properties of the phase transition. For the operator $\langle\mathcal{O}_-\rangle$, we find that the entanglement entropy decreases (or increases) with the increase of the Born–Infeld parameter b in the metal (or superconducting) phase. For the operator $\langle\mathcal{O}_+\rangle$, we observe that, with the increase of the Born–Infeld parameter, the entanglement entropy in the metal phase decreases monotonously but the entropy in the superconducting phase first increases and forms a peak at some threshold b_T, then decreases continuously. Moreover, the value of b_T becomes smaller as the width of the subsystem A decreases.
© 2014 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/3.0/). Funded by SCOAP[3].

1. Introduction

As the holographic principle provides a new insight into the investigation of strongly interacting condensed matter systems [1,2], there are a lot of works applying the anti-de Sitter/conformal

* Corresponding author.
E-mail address: jljing@hunnu.edu.cn (J. Jing).

http://dx.doi.org/10.1016/j.nuclphysb.2014.10.007
0550-3213/© 2014 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/3.0/). Funded by SCOAP[3].

field theory (AdS/CFT) duality [3–5] to condensed matter physics and in particular to superconductivity [6–22]. It states that the bulk AdS black hole becomes unstable and scalar hair condenses as one tunes the temperature for black hole. As a matter of fact, in order to understand the influences of the $1/N$ or $1/\lambda$ (λ is the 't Hooft coupling) corrections on the holographic superconductors, the higher derivative corrections to the gauge field should be taken into consideration. For the high order correction related to the gauge field, one of the important nonlinear electromagnetic theories is Born–Infeld electrodynamics [23–28]. As is well known, the Born–Infeld electrodynamics, which was proposed in 1934 by Born and Infeld to avoid the infinite self-energies for charged point particles arising in Maxwell theory [23], displays good physical properties including the absence of shock waves and birefringence. It was also found that the Born–Infeld electrodynamics is the only possible nonlinear version of electrodynamics that is invariant under electromagnetic duality transformation [24]. Jing and Chen observed that the Born–Infeld coupling parameter makes it harder for the scalar condensation to form [29]. Then, the analytic study of properties of holographic superconductors in Born–Infeld electrodynamics was presented in Ref. [30]. In this paper, we would like to investigate the phase transition in the Born–Infeld electrodynamics with full backreaction of the matter fields electrodynamics on the AdS black hole geometry.

Recently, according to the AdS/CFT duality, Ryu and Takayanagi [31,32] have presented a proposal to compute the entanglement entropy of conformal field theories (CFTs) from the minimal area surface in gravity side. Since this proposal provides a simple and elegant way to calculate the entanglement entropy of a strongly coupled system which has a gravity dual, the holographic entanglement entropy is widely used to study various properties of holographic superconductors at low temperatures [33–41]. The entanglement entropy in the metal/superconductor system was studied in Ref. [42]. It was shown that the entanglement entropy in superconducting phase is always less than the one in the metal case and the entropy as a function of temperature is found to have a discontinuous slop at the transition temperature T_c in the case of the second order phase transition. Ref. [43] considered the case with higher derivative corrections and studied the holographic entanglement entropy in Gauss–Bonnet gravity. Ref. [44] studied the holographic entanglement entropy for general higher derivative gravity and proposed a general formula for calculating the entanglement entropy in theories dual to higher derivative gravity. Then, the holographic entanglement entropy in the insulator/superconductor model was studied in Refs. [45–48] and it turned out that the entanglement entropy is a good probe to investigate the holographic phase transition. Furthermore, Kuang et al. examined the properties of the entanglement entropy in the four-dimensional AdS black hole and found that the entanglement entropy can be considered as a probe of the proximity effect of a superconducting system by using the gauge/gravity duality in a fully backreacted gravity system [49]. More recently, the entanglement entropy of general Stückelberg models both in AdS soliton and AdS black hole backgrounds with full backreaction was studied in Ref. [50]. However, the models mentioned above are all in the frame of Maxwell electromagnetic theory. It is of interest to investigate holographic entanglement entropy in the nonlinear electromagnetic generalization. We have studied in Ref. [51] the holographic entanglement entropy in the insulator/superconductor phase transition for the Born–Infeld electrodynamics, and found that the entanglement entropy increases with the increase of the Born–Infeld factor in the superconductor phase and the critical width ℓ of confinement/deconfinement phase transition is dependent of the Born–Infeld parameter. As a further study along this line, in this paper we will extend the previous works to investigate the entanglement entropy in metal/superconductor phase transition with Born–Infeld electrodynamics. We find that the entanglement entropy decreases with the increase of the Born–Infeld parameter

Download English Version:

https://daneshyari.com/en/article/1842021

Download Persian Version:

https://daneshyari.com/article/1842021

Daneshyari.com