

Gedanken Experiments to Destroy a BTZ Black Hole

Bo Ning^{*a}, Baoyi Chen^{†b} and Feng-Li Lin^{‡c}

^a *College of Physical Science and Technology,*

Sichuan University, Chengdu, Sichuan 610065, China

^b *TAPIR, Walter Burke Institute for Theoretical Physics,*

California Institute of Technology, Pasadena, California 91125, USA

^c *Department of Physics, National Taiwan Normal University,*

No. 88, Sec. 4, Ting-Chou Road, Taipei 11677, Taiwan

Abstract

We consider gedanken experiments to destroy an extremal or near-extremal BTZ black hole by throwing matter into the horizon. These black holes are vacuum solutions to (2+1)-dimensional gravity theories, and are asymptotically AdS₃. Provided the null energy condition for the falling matter, we prove the following—(i) in a Mielke-Baekler model without ghost fields, when torsion is present, an extremal BTZ black hole can be overspun and becomes a naked conical singularity; (ii) in 3-dimensional Einstein gravity and chiral gravity, which both live in torsionless limits of Mielke-Baekler model, an extremal BTZ black hole cannot be overspun; and (iii) in both Einstein gravity and chiral gravity, a near-extremal BTZ black hole cannot be overspun, leaving the weak cosmic censorship preserved. To obtain these results, we follow the analysis of Sorce and Wald on their gedanken experiments to destroy a Kerr-Newman black hole, and calculate the second order corrections to the black hole mass. Furthermore, Wald's type of gedanken experiment provides an operational procedure of proving the third law of black hole mechanics. Through the AdS/CFT correspondence, our results on BTZ black holes also indicate that a third law of thermodynamics holds for the holographic conformal field theories dual to 3-dimensional Einstein gravity and chiral gravity.

*ningbo@scu.edu.cn

†baoyi@tapir.caltech.edu

‡fengli.lin@gmail.com