Contents

Introduction **1**

I Background material **5**

1 Charges in the metric formulation **7**
1.1 Charges in gauge theory . . . 7
1.2 Covariant phase space formalism . . . 9
1.2.1 Iyer-Wald formalism . . . 9
1.2.2 BBC formalism . . . 11

2 Aspects of the AdS_3/CFT_2 correspondence **15**
2.1 AdS_3 gravity and boundary conditions . . . 15
2.2 CFT_2 and Cardy formula . . . 17

3 Warped duality **21**
3.1 Warped spacetimes . . . 21
3.2 Warped conformal field theory and warped Cardy formula . . . 23
3.3 Quadratic ensemble . . . 25

4 Flat duality **29**

5 Thermodynamics **33**
5.1 First law . . . 33
5.1.1 Inner thermodynamics . . . 34
5.2 Phase transition . . . 35

II Original contributions **39**

6 Maximally symmetric solutions in higher derivative theories **41**
6.1 Method . . . 42
6.2 BTZ black holes in higher derivative theories . . . 43
6.2.1 Symmetries . . . 43
6.2.2 Charges and entropy matching . . . 44
6.2.3 Phase transition . . . 46
6.3 BTZ black holes in TMG . . . 47
6.4 Flat space cosmologies . . . 49
6.4.1 Charges and entropy . . . 49
6.4.2 Phase transition . . . 50

7 Warped gravity in higher derivative theories **53**
7.1 Geometry of WAdS_3 and Wald entropy . . . 53
7.1.1 Symmetries and curvature tensors . . . 53
7.1.2 Wald entropy of warped black holes . . . 55
7.2 Charges of warped black holes . . . 56
7.2.1 Lagrangians without derivative of the Ricci . . . 56
7.2.2 Lagrangians with derivatives of the Ricci . . . 57
7.3 WAdS_3 entropy in higher curvature theories: examples . . . 58
7.3.1 $L = aR - \Lambda + bR^2 + cR_{\mu\nu}R^{\mu\nu} + m_1 R^{\nu}_{\mu} R^{\rho}_{\nu} R^{\mu}_{\rho} + m_2 R_{\mu\nu}R^{\mu\nu}R + m_3\, R^3$ . . . 58
7.3.2 Corrections for a theory with $(\nabla^a R^{bc})^2$ . . . 59
7.4 Phase Transitions . . . 60
7.4.1 Generic theory without gravitational anomaly . . . 60
7.4.2 TMG . . . 61
7.5 Central charges from inner horizon thermodynamics . . . 63

8 Boundary conditions for three dimensional black strings **67**
8.1 Black string . . . 67
8.2 Phase Space . . . 68
8.2.1 Equations of motion in Bondi gauge . . . 68
8.2.2 Residual symmetries . . . 71
8.2.3 Charges . . . 72
8.2.4 Phase space . . . 77
8.3 Thermodynamics . . . 77

Conclusions **81**

Appendices **83**

A Conventions and useful formulas **85**
A.1 Levi-Civita tensor . . . 85
A.2 Metric . . . 85
A.3 p-forms . . . 85
A.4 $(n-p)$-forms . . . 86

B On-shell conditions for theories without derivatives of Riemann tensor for warped geometries **87**

C Computations of $\Theta^{(s)}$ and $Q^{(s)}_{\xi}$ (for $s \geq 1$) for warped geometries **91**
C.1 Putting the $Z\delta R$ term in the form of Eq. (C.1) . . . 92

Bibliography **93**