



## Prof. CAI Ronggen and Cooperators Awarded for studies on dynamical and thermodynamical properties and the intrinsic relation between them in gravity

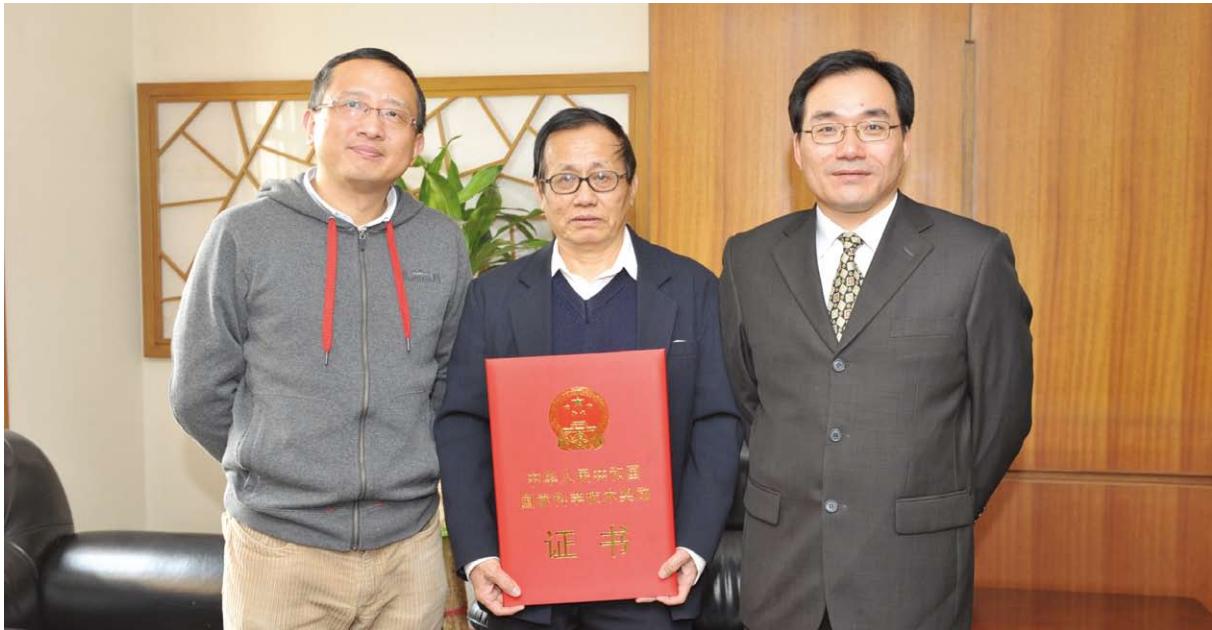
Prof. CAI Ronggen (Cai, Rong-Gen), WANG Bin (Wang, Bin) and ZHANG Yuanzhong (Zhang, Yuan-Zhong) at the CAS Institute of Theoretical Physics and their collaborators were awarded a second prize from the State Natural Science Award for their systematic research on the dynamical and thermodynamical properties and the relations between them in gravity.

For forty years, dynamical and thermodynamical properties in gravity and the relations therein have been under heated discussions. In the 1970s, combining general relativity with quantum mechanics, S. W. Hawking and some other renowned physicists articulated that black holes might possess thermodynamical properties. This pioneer discovery stimulated Nobel Prize winner Gerard 't Hooft to propose in 1993 the concept of holography in gravity, which is considered an important character distinguishing gravity from other three fundamental interactions in Nature. CAI and his cooperators have devoted themselves to the relevant research since the beginning of the 1990s, and achieved some encouraging results.

First of all, they found a new solution to the Einstein

field equations, the Gauss-Bonnet black hole solution. Sometimes the new solution is called the “Boulware-Deser-Cai black hole solution” in the literature. It has been recognized as one of the three original works on Gauss-Bonnet black holes and has inspired various follow-up studies. In addition, they found a topological de Sitter spacetime solution and drawing on it they checked an important conjecture on the upper bound of the mass in de Sitter spacetime.

The team also carried out some studies on dynamical properties of the charged anti-de Sitter black hole. For the small anti-de Sitter black hole, they found that the quasinormal frequency does not change with the black hole temperature, which cleared some theoretical controversy on this issue in the literature. They also made some studies on the evolution of a scalar field coupled to the curvature in topological black hole spacetimes and revealed that topology can imprint in the perturbation behaviors. Through the Cardy-Verlinde formula they established the connection between the black hole thermodynamics in (anti)-de-Sitter spacetime and the conformal field theory; moreover, they generalized



Prof. CAI Ronggen (right) and his cooperators, Profs. ZHANG Yuanzhong (middle) and WANG Bin at the CAS Institute of Theoretical Physics were awarded a second prize from the State Natural Science Award for their systematic research on the dynamical and thermodynamical properties and the relations between them in gravity.

the study of the thermodynamical and holographic properties to dynamical spacetimes. Their research in this field demonstrated that in the realistic inhomogeneous cosmology, thermodynamics and holography could be useful for selecting physical models to describe the universe.

The team's research also revealed the intrinsic connection between dynamics and thermodynamics of gravity, shedding new light on the fundamental property of gravity. They successfully derived the Friedmann equation by applying the first law of thermodynamics to the apparent horizon of the Friedmann-Robertson-Walker universe; moreover they discovered the Hawking radiation of the cosmological apparent horizon.

So far, CAI, WANG and ZHANG have published more than 260 papers on related research in leading peer-reviewed international journals, such as *Phys. Rev. Lett.*, *Nucl. Phys. B*, *Phys. Lett. B (PLB)*, *Phys. Rev. D*, *JHEP* and *JCAP* etc., receiving over 8,300 citations, according to the High-Energy Physics Literature Database (SPIRES-HEP) of SLAC Lab. Among them 71 papers

were cited for over 50 times, and 17 cited for over 100 times. Remarkably eight representative papers authored by them have been cited 762 times by SCI-cited journals as of Feb 28, 2011.

The results from CAI *et al.*'s research on black hole dynamics and thermodynamics have been selected as research highlights twice by *Nature China*. Their work on the Hawking radiation on the cosmological apparent horizon has been selected by the Editorial Board of the *Classical and Quantum Gravity (CQG)* as one of the journal's Highlights of 2009–2010. Their result on the interacting dark energy has been ranked as No.5 of the 10 most frequently cited papers of PLB over the past five years (2005–2010). One of their works was selected into the 100 most internationally influential papers from China in 2009. The key members of the team have been invited to serve in international organizing committees of international conferences, such as ICGA, CosPA, and APCTP Focus Program etc., and have been invited to give talks in various international symposia, conferences and workshops.