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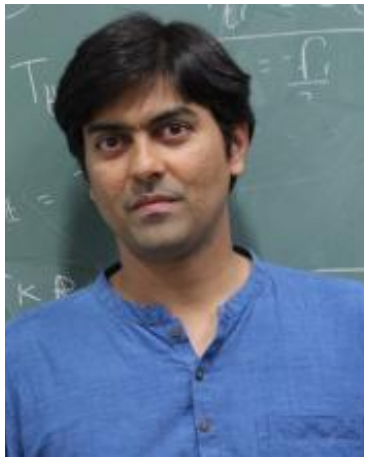
Suvrat Raju receives the 2022 Nishina Asia Award

ICTS faculty member Suvrat Raju was awarded the 10th Nishina Asia Award 2022, for "original and influential insights into the resolution of the black hole information paradox and the principle of holography in quantum gravity."



(September 15th, 2022) ICTS faculty member Suvrat Raju was awarded the 10th Nishina Asia Award 2022. The prize recognizes his "original and influential insights into the resolution of the black hole information paradox and the principle of holography in quantum gravity."

The prestigious Nishina Asia Award is given to one physicist every year by the Nishina Memorial Foundation, based in Tokyo, to recognize young Asian scientists for their outstanding achievements in the fields of basic physics.

Suvrat Raju is the second Indian physicist to win this award after Shiraz Minwalla (TIFR, Mumbai), who was awarded the Nishina Asia award in 2013.

The information paradox is an old and important problem in theoretical physics that involves a potential contradiction between the theory of quantum mechanics and the theory of gravity. This paradox was first formulated in 1976 by Stephen Hawking, almost fifty years ago.

Hawking subjected the theories of quantum mechanics and gravity to a "stress test" by studying their predictions under extreme conditions that involved the presence of black holes. Hawking argued that if a black hole is left undisturbed, it would eventually evaporate through a process that retained no information about how the black hole was initially formed. If so, black holes could be used as perfect "shredders" of information: by throwing an encyclopedia into a black hole, one could completely destroy the information contained in the encyclopedia.

This contradicts a robust principle of quantum mechanics, called "unitarity", which states that information can never be destroyed. The principle of unitarity states that if one examines the final state of any process with enough precision, it should be possible to reconstruct information about the initial state.

Although significant progress has been made toward understanding these issues, the information paradox continues to be the subject of intense research.

The Nishina Prize recognizes Raju for a key insight that helps to resolve the contradiction above. In work done over several years, Raju has argued that the combining gravitational and quantum-mechanical effects leads to a surprising phenomenon: information that naively seems to be entirely inside the black hole can be extracted by

observers outside the black hole with sufficiently precise measurements. So even as the black hole evaporates away, its information remains available outside and is not destroyed.

This remarkable effect entails a modification of our mundane notions of how information is localized. It was first postulated in a sequence of papers by Raju and Kyriakos Papadodimas (CERN) written between 2012-16 in a specific model of quantum gravity.

The Nishina prize also recognizes recent work performed in 2020-21 by Raju with several collaborators, including members of the ICTS string group. This work uncovered evidence that this delocalization of information was a general feature of quantum gravity and should be present even in the absence of black holes. This effect is now termed the “principle of holography of information”. It states that information that is present in any bounded region —whether or not that region contains a black hole — is available to observers outside the region who make sufficiently precise measurements.

In 2021, Raju also pointed out how the principle of holography of information implies a subtle error in Hawking’s argument for information loss. Hawking tacitly assumed that, even in the presence of quantum gravity, information can be localized inside the black hole; discarding this incorrect assumption leads to a resolution of the contradiction that Hawking found.

The principle of holography of information can be intuitively understood to arise due to a combination of two simple physical principles: the Gauss law of gravity and the Heisenberg uncertainty principle of quantum mechanics.

The uncertainty principle tells us that if we consider a state of a system with definite energy then it cannot be strictly localized to a finite region. So to localize information in quantum mechanics, it is necessary to use superpositions of states with different energies. In the absence of gravity, by carefully choosing the components of this superposition, it is possible to arrange for destructive interference of the quantum-mechanical wavefunction outside a bounded region and constructive interference inside it.

However, in a theory of gravity, the Gauss law implies that each state of definite energy must be accompanied by a gravitational field. This gravitational field, unlike the electromagnetic field, cannot be shielded and extends to an infinite distance. Its presence prevents the existence of states whose wavefunction interferes destructively outside some region but constructively inside a region. By extending this intuition, it is possible to show that measurements of the gravitational field and other observables outside a region can be used to reconstruct the wavefunction inside that region.

"I am very proud of Suvrat's contributions to string theory and for being a global leader in the subject of the information paradox. I am sure he will continue to do path breaking work in the future and bring more laurels to ICTS," said Rajesh Gopakumar, the Director of ICTS-TIFR.

For more details about the award please see:
https://www.nishina-mf.or.jp/news_en/2022/08/26/the-2021-the-ninth-nishina-asia-award-is-awarded-2/

For a detailed scientific citation please see:
https://nishina-mf.or.jp/project_en/award_en/

ABOUT NISHINA MEMORIAL FOUNDATION

Dr. Yoshio Nishina originated the study of nuclear physics in Japan and trained many young Japanese scientists in that field. After his passing in 1951, the Nishina Memorial Foundation was founded in 1955 with the objective of promoting physics in Japan, encouraging young and able scientists and encouraging exchange of science and culture between Japan and other countries in order to commemorate the great scholar.

ABOUT ICTS-TIFR

ICTS is a unique initiative in Indian science, which has a threefold mandate. Apart from creating an in-house research program of international quality in theoretical sciences, it aspires to become a hub that connects the Indian scientific community with the international community through its programs, thus bringing together scientists to solve some of the outstanding problems posed by nature. ICTS also actively engages with civic society in spreading awareness of exciting scientific developments and fostering the scientific temper. More information is available on the ICTS webpage.

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