

Hawking team updates soft hair theory to help solve black hole information paradox

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Hawking, Perry, and Strominger suggest that black holes might have "soft hair," low-energy quantum excitations that release information when the black hole evaporates. Credit: APS/Alan Stonebraker



(Phys.org)—Stephen Hawking, along with Malcolm Perry and Andrew Strominger has updated his ideas regarding solving the black hole information paradox. In their new paper published in the journal *Physical Review Letters*, the trio outlines their ideas regarding soft hair and black holes and why they believe it may hold the key to resolving a problem that has been causing issues for physicists for over forty years.

The black hole <u>information</u> paradox is relatively easy to understand—<u>black holes</u> theoretically suck in everything around them, including light, causing information to be lost, forever. But back in the 70's Hawking and colleagues discovered that some information escapes—it is now known as Hawking radiation—but the information that escapes is not enough to describe everything that was eaten by a given black hole, so, the question remains, what happens to the rest of the information when the black hole dies?

Trying to solve this paradox has proven to be much more difficult. But, this past January, progress was made, Hawking, Perry and Strominger proposed a possible solution to the paradox, a theory based on what they called soft hair—<u>but not everyone was convinced</u>. The idea behind the theory is that quantum excitations known as soft hairs form a halo around a black hole, holding the information for the things that were consumed. The team came to conclude this was possible by identifying two problems with the assumptions that were made back in the 70's, namely that the vacuum around black holes is unique and that black holes had no "hair."

After <u>posting their paper</u> on the preprint server *arXiv*, in January, critics were wary of the theory because it failed to explain how it was that information could be exchanged between the black hole and the soft hair. In this new paper, the trio still has not addressed this problem completely, but they have reworked the math and have found stronger evidence for the existence of soft hairs—if they can do the same for



gravity, and show that all of the information is held in the soft hairs, rather than just some, it should greatly increase the chances that one day the paradox will be solved once and for, offering relief for those who feared that the <u>paradox</u> might one day lead to having to toss out some of the most cherished theories in physics.

More information: Stephen W. Hawking et al. Soft Hair on Black Holes, *Physical Review Letters* (2016). <u>DOI:</u> <u>10.1103/PhysRevLett.116.231301</u>

ABSTRACT

It has recently been shown that Bondi-van der Burg-Metzner-Sachs supertranslation symmetries imply an infinite number of conservation laws for all gravitational theories in asymptotically Minkowskian spacetimes. These laws require black holes to carry a large amount of soft (i.e., zero-energy) supertranslation hair. The presence of a Maxwell field similarly implies soft electric hair. This Letter gives an explicit description of soft hair in terms of soft gravitons or photons on the black hole horizon, and shows that complete information about their quantum state is stored on a holographic plate at the future boundary of the horizon. Charge conservation is used to give an infinite number of exact relations between the evaporation products of black holes which have different soft hair but are otherwise identical. It is further argued that soft hair which is spatially localized to much less than a Planck length cannot be excited in a physically realizable process, giving an effective number of soft degrees of freedom proportional to the horizon area in Planck units.

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