Title: Possible Astrophysical Observables of Quantum Gravity Effects near Black Holes

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Abstract: Recent implications of results from quantum information theory applied to black holes has led to the confusing conclusions that requires either abandoning the equivalence principle (e.g. the firewall picture), or the no-hair theorem (e.g. the fuzzball picture), or even more unpalatable options. The recent discovery of a pulsar orbiting a black hole opens up new possibilities for tests of theories of gravity. We examine possible observational effects of semiclassical quantum gravity in the vicinity of black holes, as probed by pulsars and event horizon telescope imaging of flares. Pulsar radiation is observable at wavelengths only two orders of magnitude shorter than the Hawking radiation, so precision interferometry of lensed pulsar images may shed light on the quantum gravitational processes and interaction of Hawking radiation with the spacetime near the black hole. This paper discusses the impact on the pulsar radiation interference pattern, which is observable through the modulation index in the foreseeable future, and discusses a possible classical limit of BHC.

Introduction
Black Hole Dilemma
Lensing
Near horizon tests
Summary

A Potential Astrophysical Test of Quantum Gravity

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Strings Crazy Ideas

Magnetar PSR J1745-2900



(credit: MPIfR/Ralph Eatough) mysterious discovery in 2013, orbiting galactic center black hole. Rafikov-Lai (2006): precision GR test?

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Black Hole Information



Hawking (1974): black holes radiate: $T = hc/k_B r_s \sim \mu K$. High entropy: number of photons emitted $\sim mc^2/k_B T \sim S/k_B \sim 10^{77}$. Very slow: one photon of $\lambda \sim r_s \sim \text{km}$ each $\lambda/c \sim \text{ms.}$ (1981): information loss? Evaporation is a Schwinger mechanism, does not depend on inside of black hole.

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Entropy solution

- string theory to the rescue!
- Strominger-Vafa (1996): counting of microstates
- unitarity saved?
- Stringy counting not possible in classical limit: what happens with Hawking's argument?

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Strings Crazy Ideas

Firewalls: kill the messenger

- Almheiri, Marolf, Polchinski, Sully (2012)
- Schwinger pair creation at horizon: maximal entanglement
- Iate time photons must correlate with early photons: purity
- Quantum monogamy of entanglement violated!
- Solution: firewall near horizon kills would-be experimentalists/reporters who reveal violations
- Hawking 2014: microscopic violation of time reversibility?

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Orders of orders of magnitude

- ► Saha, partition function: $\frac{P(n_1)}{P(n_0)} = \frac{g_1}{g_0} \exp\left(-\frac{\Delta E}{k_B T}\right)$
- probability to observe in substantially non-Schwarzschild state:
- $\blacktriangleright \Delta E \sim mc^2$
- $\blacktriangleright \ \frac{\Delta E}{k_B T} \sim 10^{77}$
- $S_1 \sim k_B \log g_1 \gtrsim 10^{77}$
- no-hair may be a great mis-estimate, off by 10⁷⁷ orders of magnitude!

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