On LUXE's relation to Hawking Radiation
(My Mickey-Mouse Explanation)

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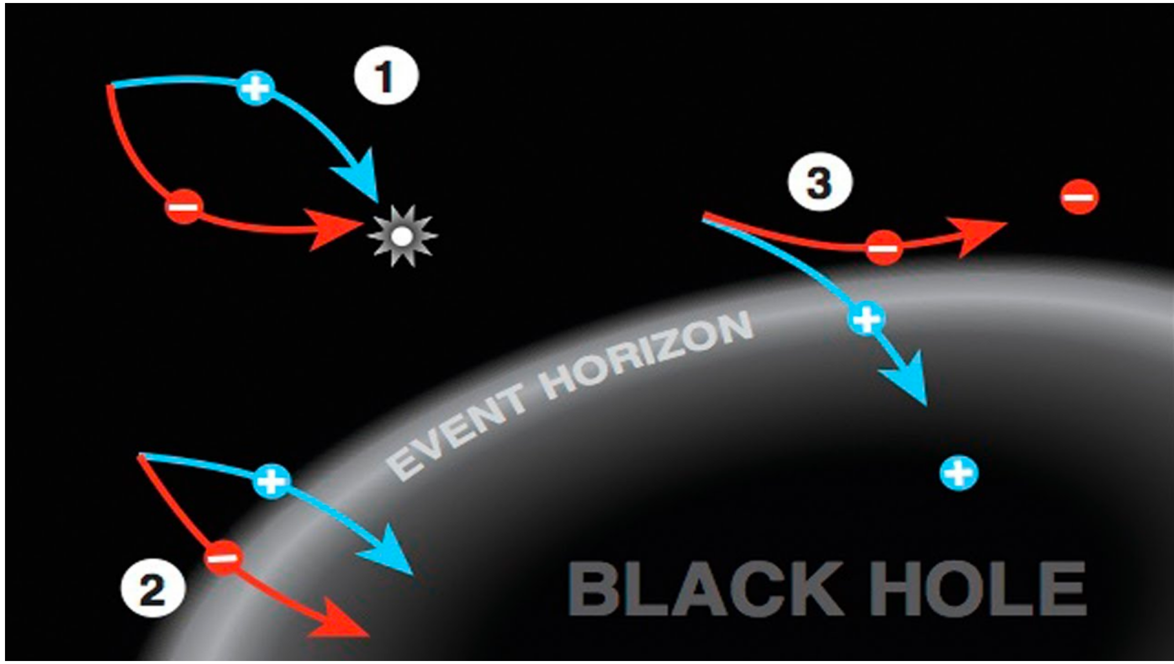
Introduction

- Whenever I meet people and tell them about LUXE I discuss the physics case with them
- Recently chatted with Hitoshi Murayama (Berkeley and IPMU) and he sent me slides he made discussing how an experiment testing the Schwinger regime is related to Hawking radiation: ”This may be the closest we will ever get to testing Hawking radiation”
- I am just reproducing here the very simple basic argument relating Hawking radiation to our experiment

What is Hawking Radiation?

- Black-body radiation released by black holes at event horizon due to quantum fluctuations
  - Quantum fluctuations of photons into electron-positron pairs
  - Pair can be separated if the gravitational field large enough
    - One part of pair goes into BH
    - The other one escapes BH

Main scientific achievement of Stephen Hawking (1974)



Particle Creation by Black Holes

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Abstract. In the classical theory black holes can only absorb and not emit particles. However it is shown that quantum mechanical effects cause black holes to create and emit particles as if they were hot bodies with temperature $\frac{\hbar\kappa}{2\pi k} \approx 10^{-6}\left(\frac{M_\odot}{M}\right)$ °K where κ is the surface gravity of the black hole. This thermal emission leads to a slow decrease in the mass of the black hole and to its eventual disappearance: any primordial black hole of mass less than about 10^{15} g would have evaporated by now. Although these quantum effects violate the classical law that the area of the event horizon of a black hole cannot decrease, there remains a Generalized Second Law: $S+\frac{1}{4}A$ never decreases where S is the entropy of matter outside black holes and A is the sum of the surface areas of the event horizons. This shows that gravitational collapse converts the baryons and leptons in the collapsing body into entropy. It is tempting to speculate that this might be the reason why the Universe contains so much entropy per baryon.

(22 pages, >7000 citations)

The (simple) math of Hawking radiation

- Energy needed to create on-shell e^+e^- pair: $\Delta E = 2mc^2$
- Minimal time (using Heisenberg's uncertainty principle):
  - $\Delta t \geq \frac{\hbar}{\Delta E}$ => $t_{min} = \frac{\hbar}{2mc^2}$
- Minimum distance between pair: $d_{min} = 2c\Delta t_{min} = \frac{\hbar}{mc}$
  - since they both fly with c away from each other
- Grav. Field near the event horizon: $F = \frac{G_N M m}{r_s^2}$
- Schwarzschild radius $r_s = \frac{2G_N M}{c^2}$. => $F = \frac{mc^4}{4G_N M}$
- Energy to separate pair: $E = F d_{min} = \frac{mc^4}{4G_N M} \times \frac{\hbar}{mc} = \frac{\hbar c^3}{4G_N M}$

Hawking radiation possible if virtual pair becomes real, i.e. $\frac{\hbar c^3}{4G_N M} > 2mc^2$

Our experiment: use E-field instead of G-field

- The force is $F = e\varepsilon$
- Energy to separate pair: $E = Fd_{min} = \frac{\hbar e\varepsilon}{mc}$
- Virtual pair becomes real if $E = Fd_{min} = \frac{\hbar e\varepsilon}{mc} > 2mc^2$

- => i.e. if $\varepsilon > \frac{2m^2c^3}{\hbar e} = 2\varepsilon_{Schwinger}$