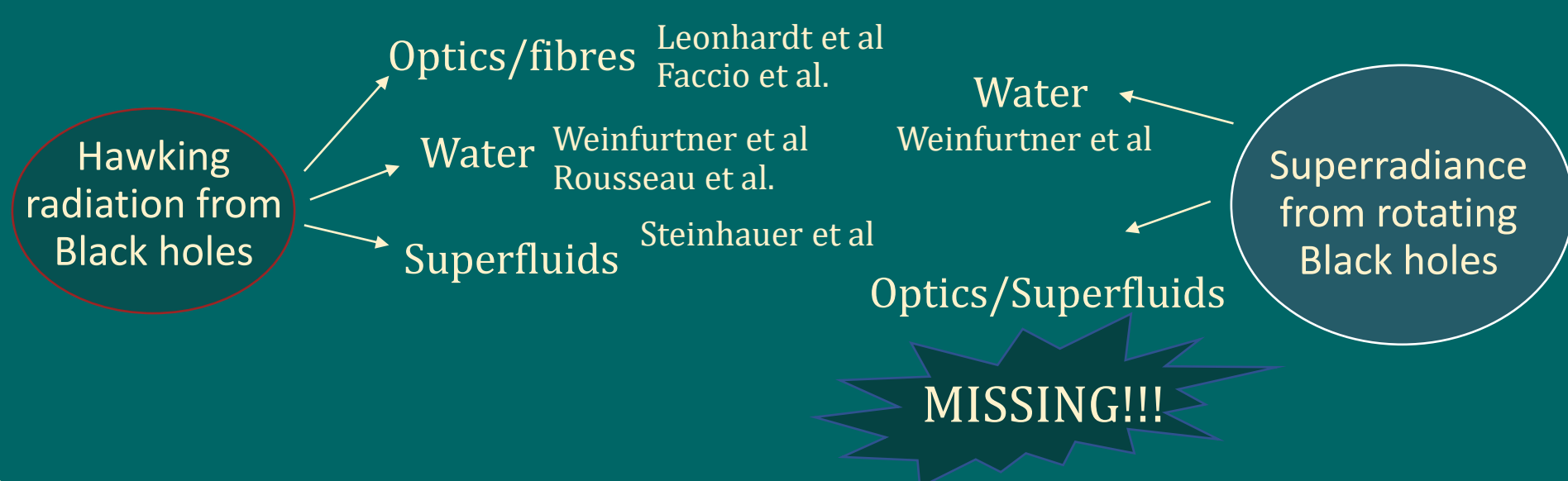


We have performed an experiment in which we measure the amplification of positive norm waves and see the trapping of the negative norm counterpart inside the ergoregion.

Motivation

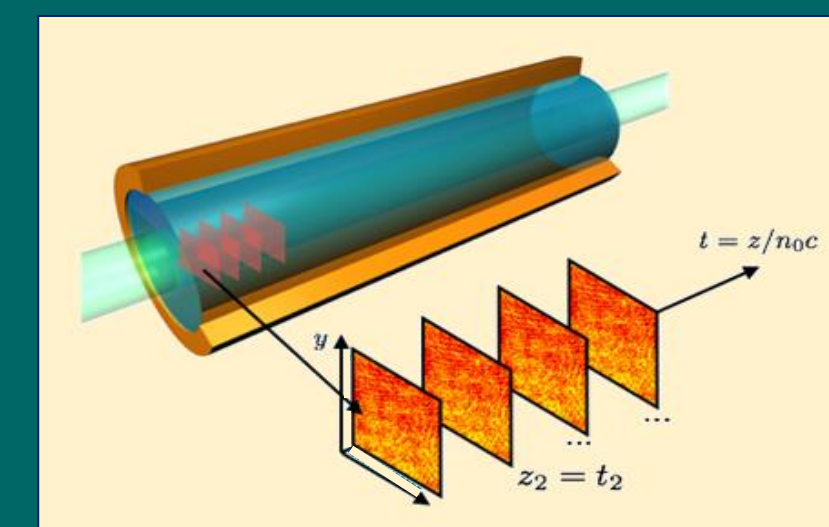
Some astrophysical phenomena are too hard to study (with current technology). To solve this issue scientist created analog experimental systems that reproduce underlying (simplified) equations and verify the predictions. Implicit, non-trivial assumption: equations describing one system can be used to describe a completely different system.



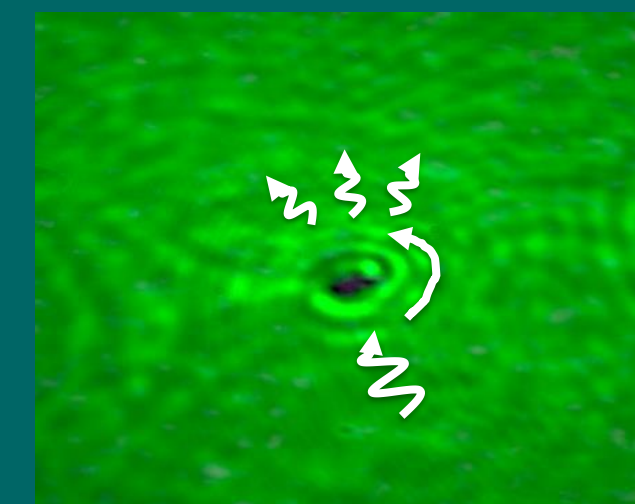
First Measurement of Penrose Superradiance in a Photon Superfluid

A photon fluid is created by propagating a laser beam through a defocusing nonlinear medium such that the photons in the beam act as a gas of weakly interacting particles

Photons Superfluids



D. Vocke, D. Faccio et al. Optica 2, 484 (2015)



$$i \frac{\partial E}{\partial z} + \frac{1}{2} \frac{\partial^2 E}{\partial x^2} - P \Delta n [|E|^2] E = 0$$

$$E = \underbrace{E_{pump}}_{\text{Background}} + \underbrace{E_{signal} + E_{idler}}_{\text{Perturbation}}$$

Theoretical Results

CONDITIONS FOR HAVING SUPERRADIANCE

- 1. Phase Matching Condition**
 $\Delta K > 0 \Rightarrow \omega - n\Omega < 0$
- 2. $\omega_i < 0 \Rightarrow$ The idler mode is trapped in r_e (negative current)**
- 3. $n = m - \ell > 0$**

MC Braidotti, D. Faccio and E. Wright, Phys. Rev. Lett. **125**, 193902 (2020)

Conserved quantity is the current J_0

$$J_0 = (|E_{signal}|^2 - |E_{idler}|^2)$$

$$Reflection = \int_{r_e}^{\infty} (|E_{signal}|^2 - |E_{idler}|^2) r dr$$

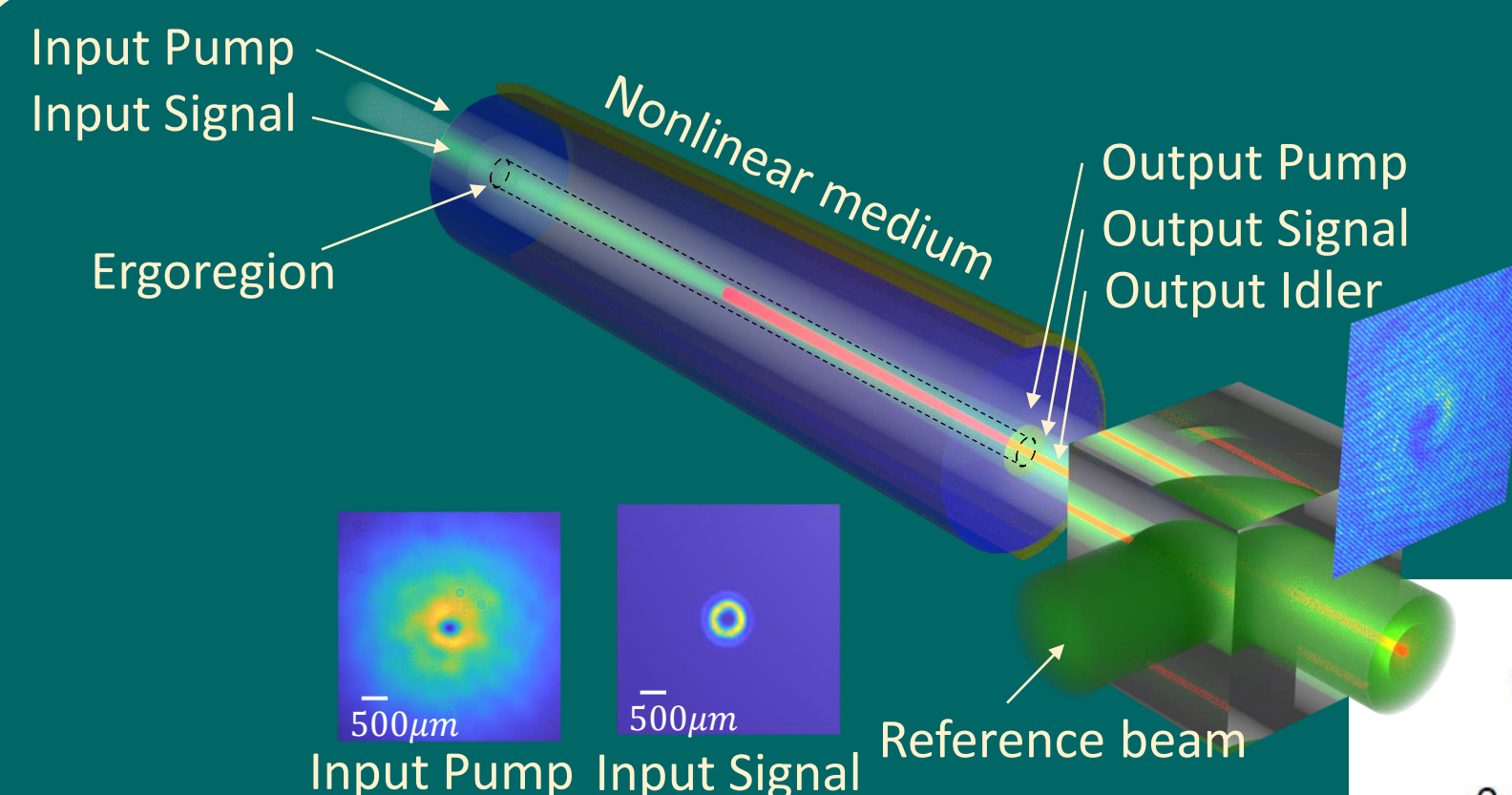
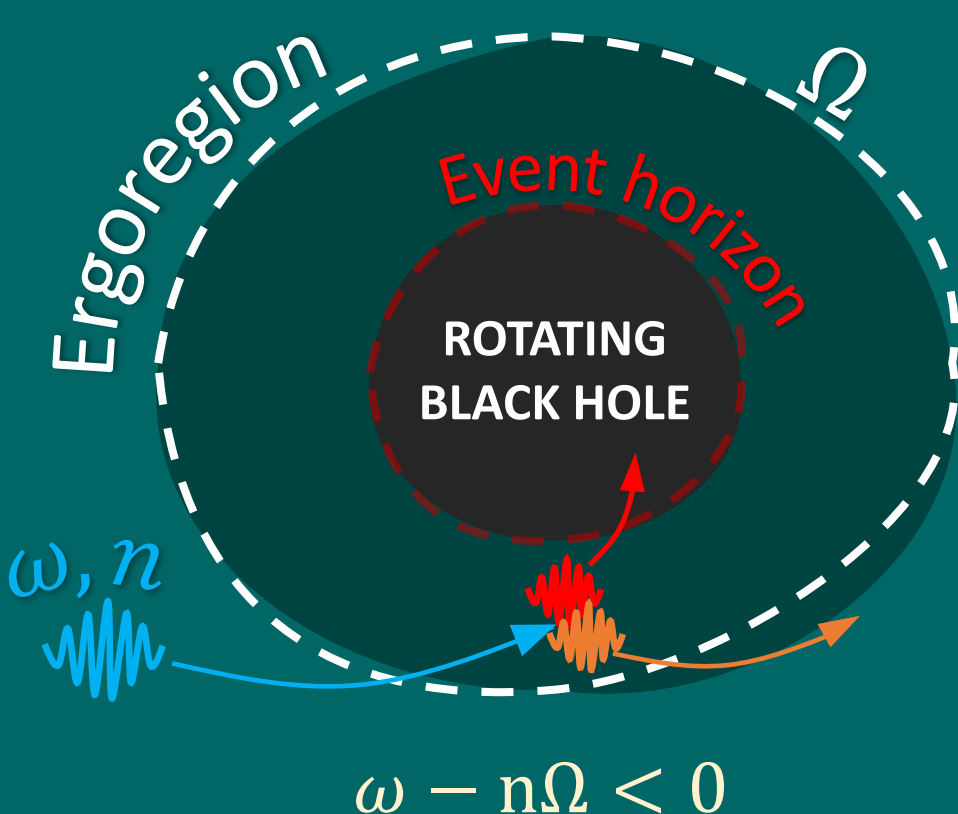
Superradiance means having Reflection > 1

Negative Current J_0 near the ergoregion r_e

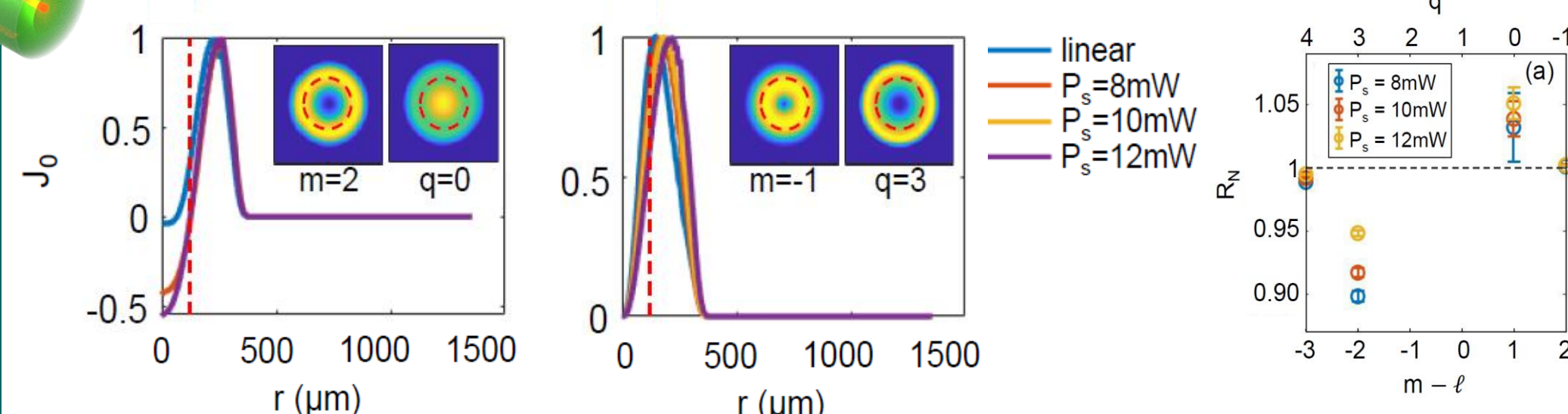
Penrose Superradiance

Superradiance is a scattering effect whereby positive norm waves reflected from a moving medium are amplified, at expenses of the negative norm counterpart that gets trapped inside the black hole.

General Relativity and Gravitation, Vol. 34 (2002) "Gravitational Collapse: The Role of General Relativity", 1969 R. Penrose



Experimental setup



- 1. Phase Matching** creation of idler wave!
- 2. $\omega_i < 0 \Rightarrow$ The idler mode is trapped in r_e (negative current)**
- 3. $n = m - \ell > 0$**

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