Introduction (plus some science. . .)

Ralf Schützhold

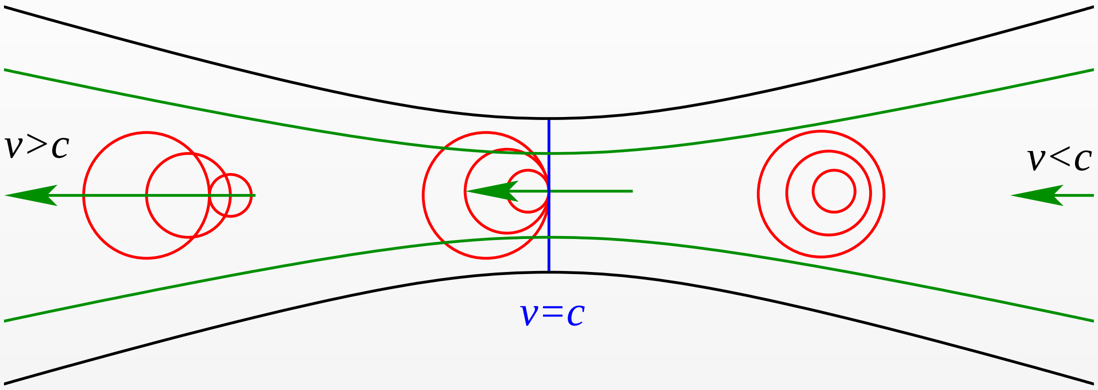
Fakultät für Physik

Universität Duisburg-Essen

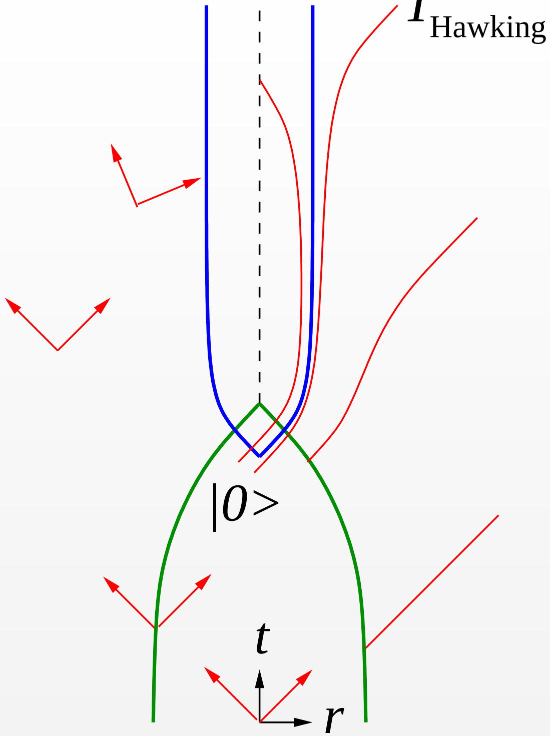
Organization

- joint session C4 + D4
  (experimental/observational aspects…)
- 15 minutes for **everything**
  ($\rightarrow$ laptop)
- schedule changes
  (waiting list)
- students and post-docs
  (nomination for prizes)

Analogue Gravity

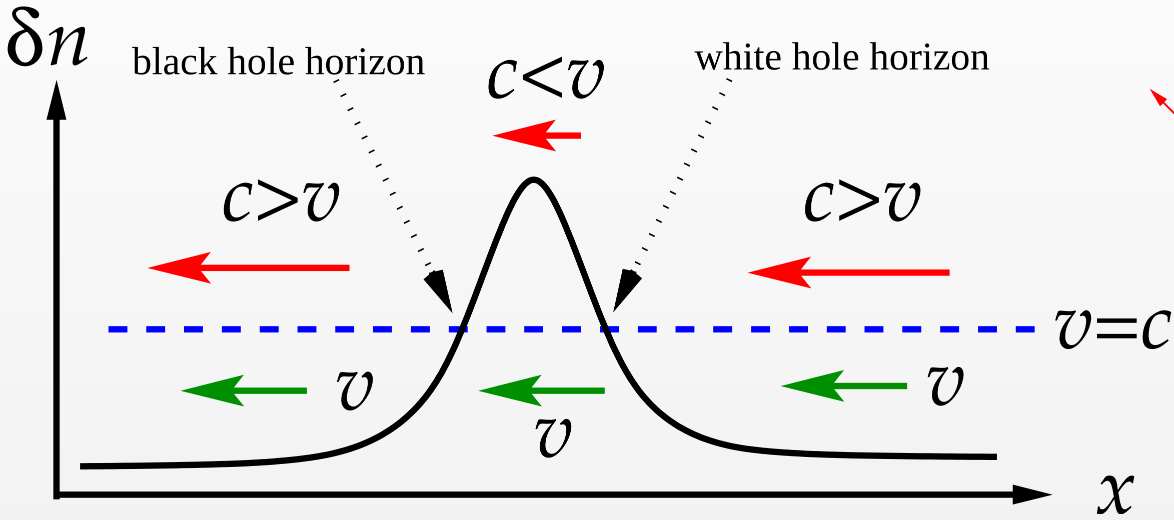


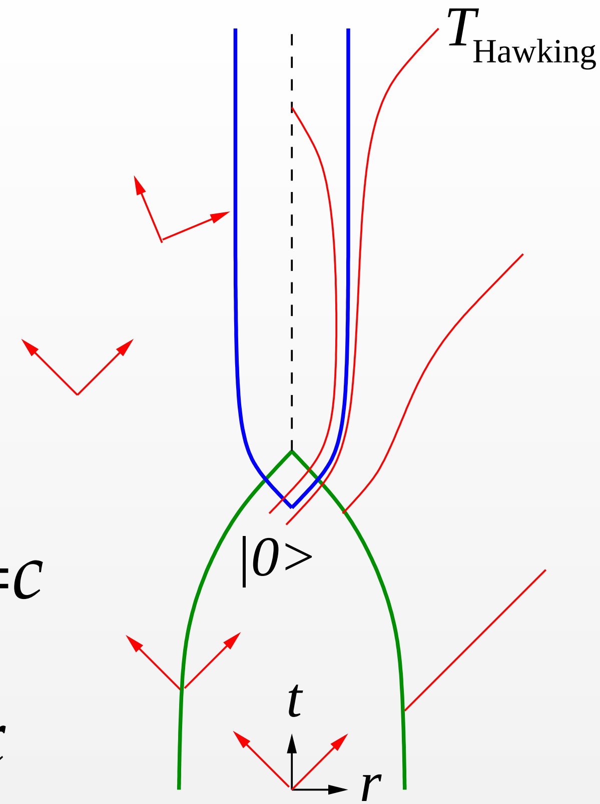
W. G. Unruh, Phys. Rev. Lett. **46**, 1351 (1981).



- sound, e.g., Bose-Einstein condensates
  → talks by J. Steinhauer and R. Dudley
- light, e.g., non-linear dielectrics, meta-materials
  → talk by A. Prain
- water waves (classical effects)
  → ask S. Weinfurtner…
- theory toy models ↔ experiments
  e.g., dispersion relation → talks today + Tue

Moving Pulse





W. G. Unruh, Phys. Rev. Lett. **46**, 1351 (1981). R. S., W. G. Unruh, ibid. **95**, 031301 (2005).

Moving pulse in non-linear dielectric medium

"The same equations have the same solutions."

$$T_{\mathrm{Hawking}} = \frac{1}{8\pi M} \frac{\hbar c^3}{G_{\mathrm{N}} k_{\mathrm{B}}} \rightarrow \frac{\hbar}{2\pi\, k_{\mathrm{B}}} \frac{\partial c}{\partial r}$$

F. Belgiorno *et al*, D. Faccio *et al*, U. Leonhardt *et al*,
F. König *et al*, S. Finazzi & I. Carusotto, etc.

Analytic Derivation

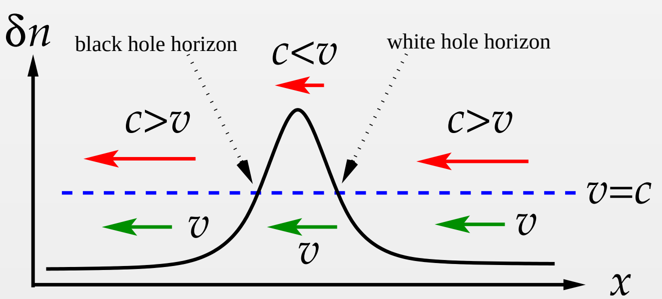
Hopfield model (one pair of Sellmeier coefficients)

$$\mathcal{L} = \frac{1}{2}\left[(\partial_t A)^2 - (\partial_x A)^2 + (\partial_t \Psi)^2 - \Omega^2\Psi^2 + g\Psi\partial_t A\right]$$

Moving pulse $\Omega(t,x) = \Omega(x - vt)$ (e.g., Stark shift)

Malte F. Linder, R.S., William G. Unruh, Phys. Rev. D **93**, 104010 (2016).

Analogue of Hawking radiation



$$\langle \hat{n}_\omega^{\rm out}\rangle = |\beta_\omega^2| = \frac{\Gamma_\omega}{e^{\omega/T_{\rm H}} - 1}$$

Gray-body factor due to mixing

$$\hat{a}_\omega^{\rm Hawking} = \alpha_\omega \hat{a}_\omega + \beta_\omega \hat{a}_\omega^\dagger + \eta_\omega \hat{a}_\omega^{\rightarrow}$$

Hawking temperature $T_{\rm H} \propto \partial_x \Omega$

$$\left|\frac{\beta_\omega^2}{\alpha_\omega^2}\right| = \exp\left\{-\frac{\omega}{T_{\rm H}}\right\}$$