Correlations of density fluctuations: From star radius to analog Hawking radiation

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In collaboration with:

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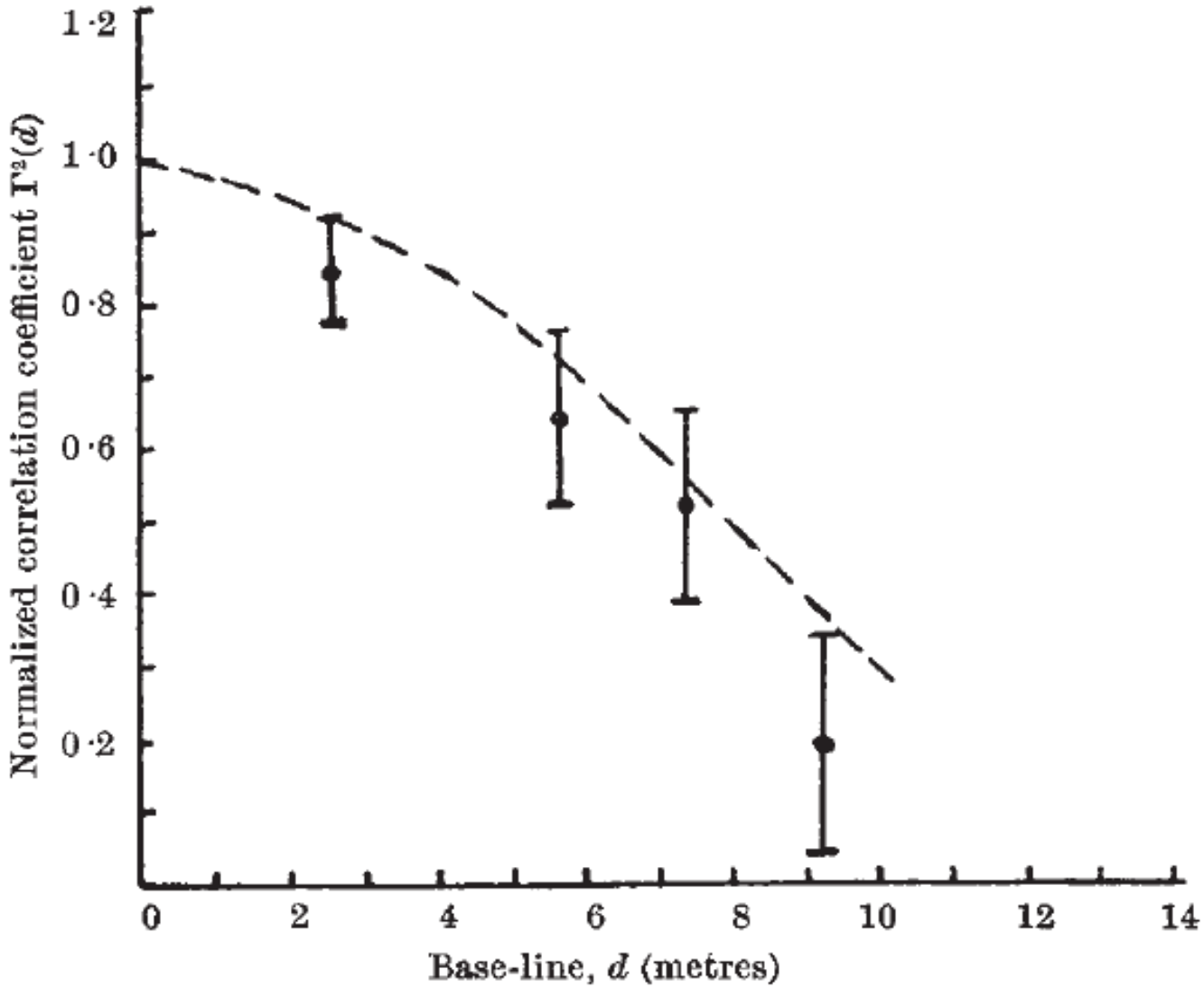
- Serena Fagnocchi and Roberto Balbinot (Università di Bologna, Italy)
- Alessandro Fabbri and Carlos Mayoral (IFIC - Univ. de Valencia and CSIC, Spain)
- Nicolas Pavloff and Renaud Parentani (Université Paris-Sud, Orsay, France)

IX SIGRAV school on *Analogue Gravity*, Como, May 16-21, 2011



From: R. Hanbury-Brown and R. Q. Twiss, Nature 178, 1046 (1956)

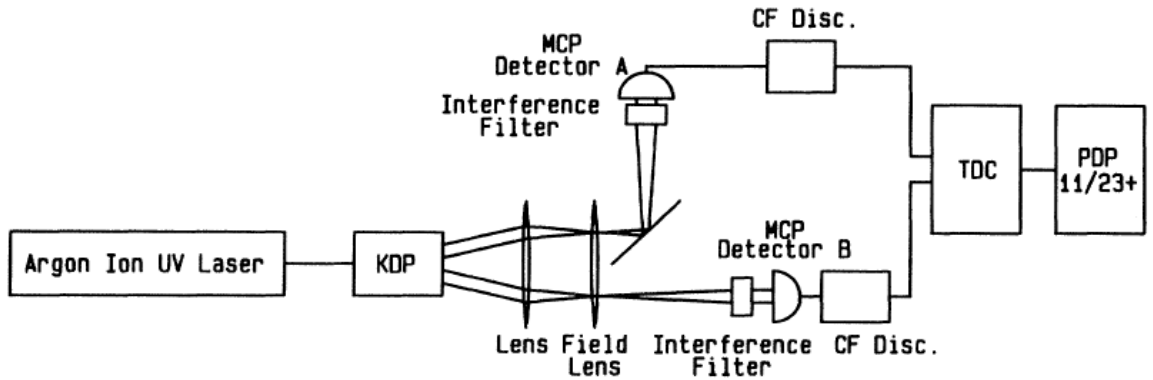
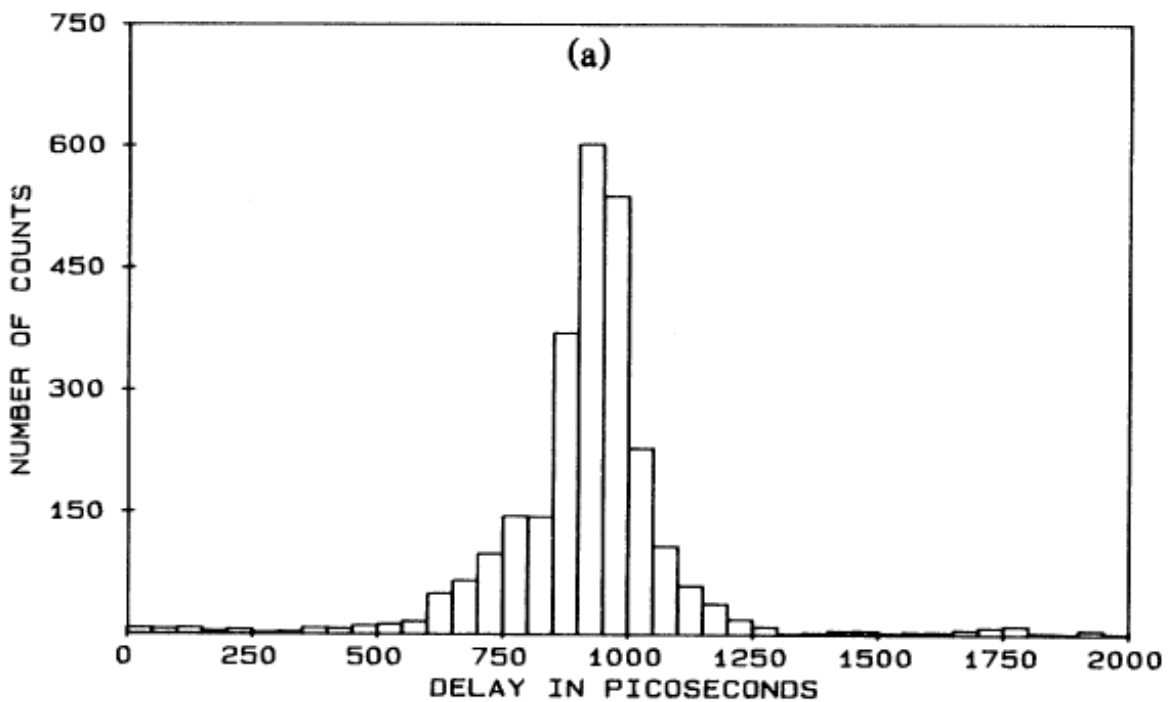
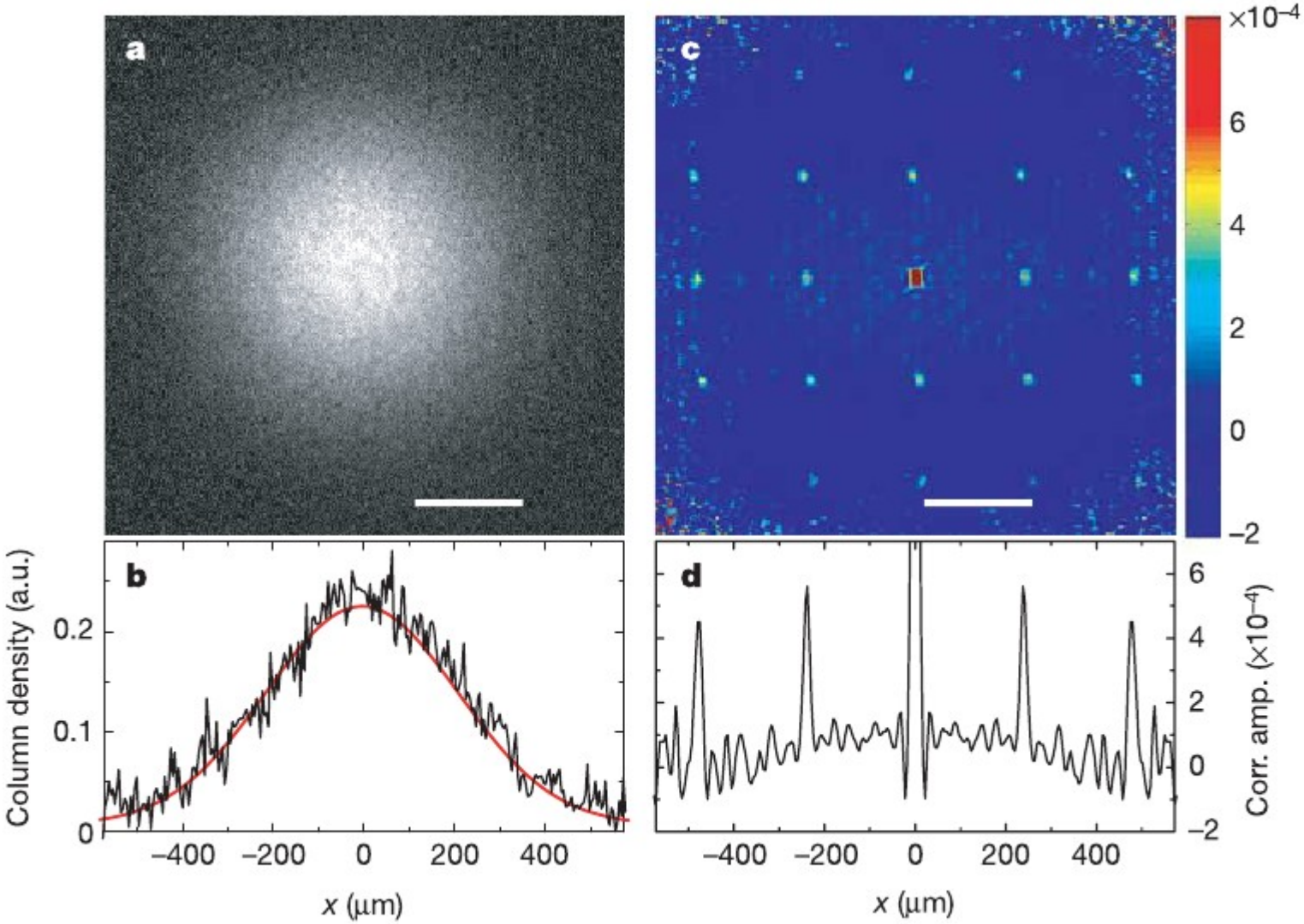


FIG. 1. Outline of the apparatus.



From: Friberg, Hong, Mandel, PRL 54, 2011 (1985)



From: Foelling, Gerbier, Widera, Mandel, Gericke, Bloch, Nature 434, 481 (2005)

Density correlations: the movie

IC, S.Fagnocchi, A.Recati, R.Balbinot, A.Fabbri, New J. Phys. 10, 103001 (2008)

A snapshot of density correlations

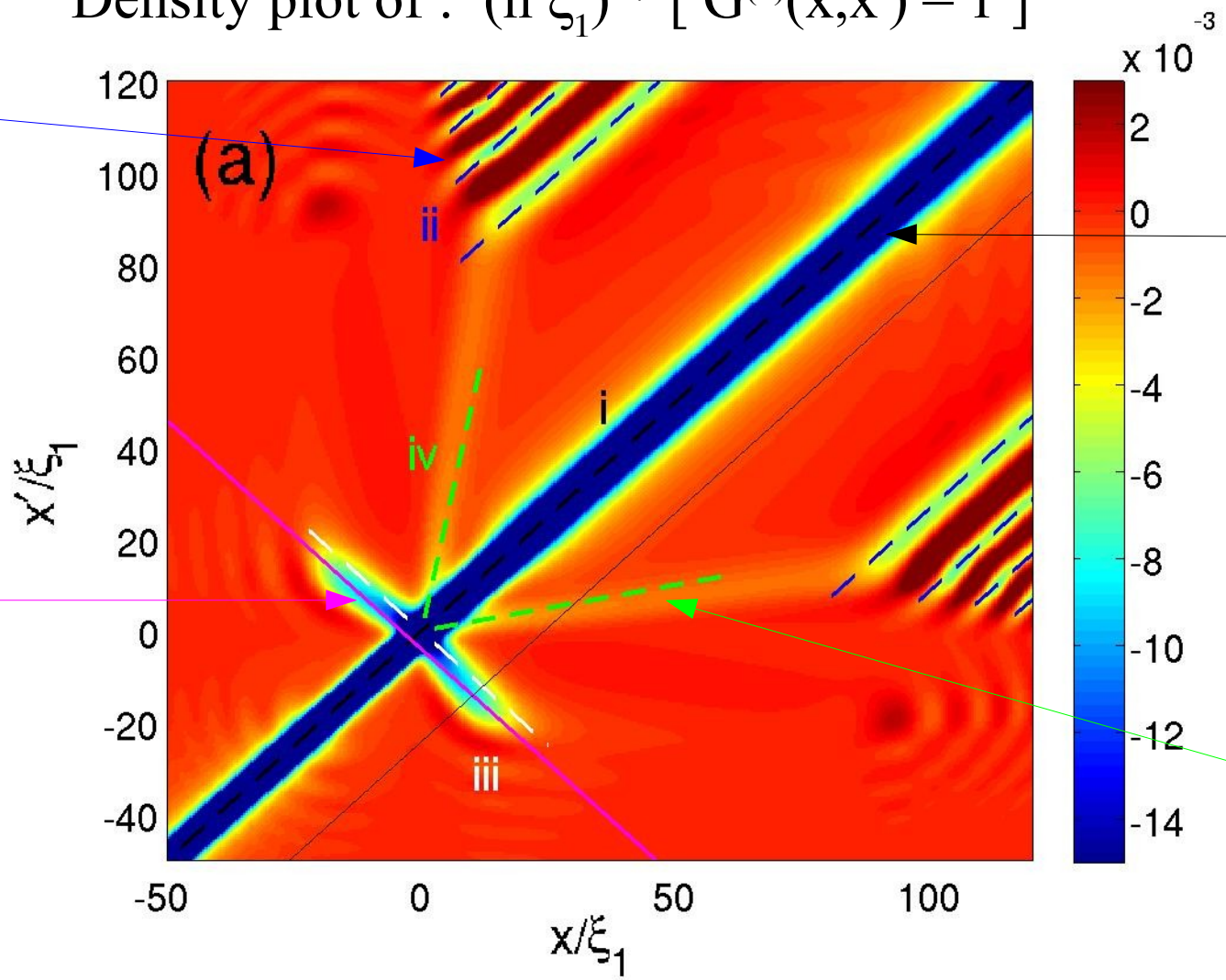
Density plot of : $(n\,\xi_1) * [\,G^{(2)}(x,x') - 1\,]$

(ii) Dynamical Casimir emission

(i) Many-body antibunching

(iii) Hawking in / out

(iv) Hawking in / in

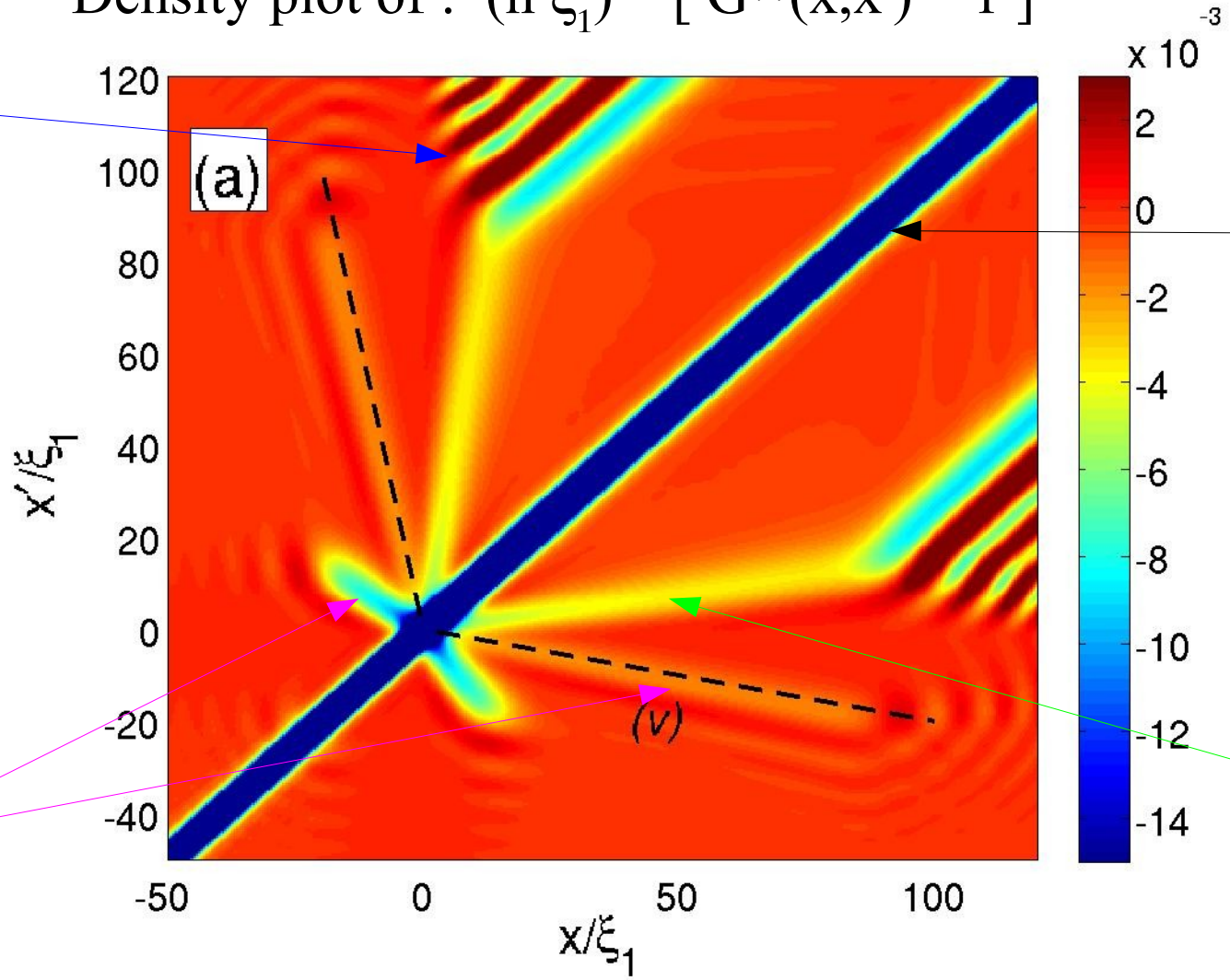


IC, S.Fagnocchi, A.Recati, R.Balbinot, A.Fabbri, New J. Phys. 10, 103001 (2008)

Stimulated Hawking radiation at finite T

Density plot of : $(n\,\xi_1) * [\,G^{(2)}(x,x') - 1\,]$

(ii) Dynamical Casimir emission



(i) Many-body antibunching

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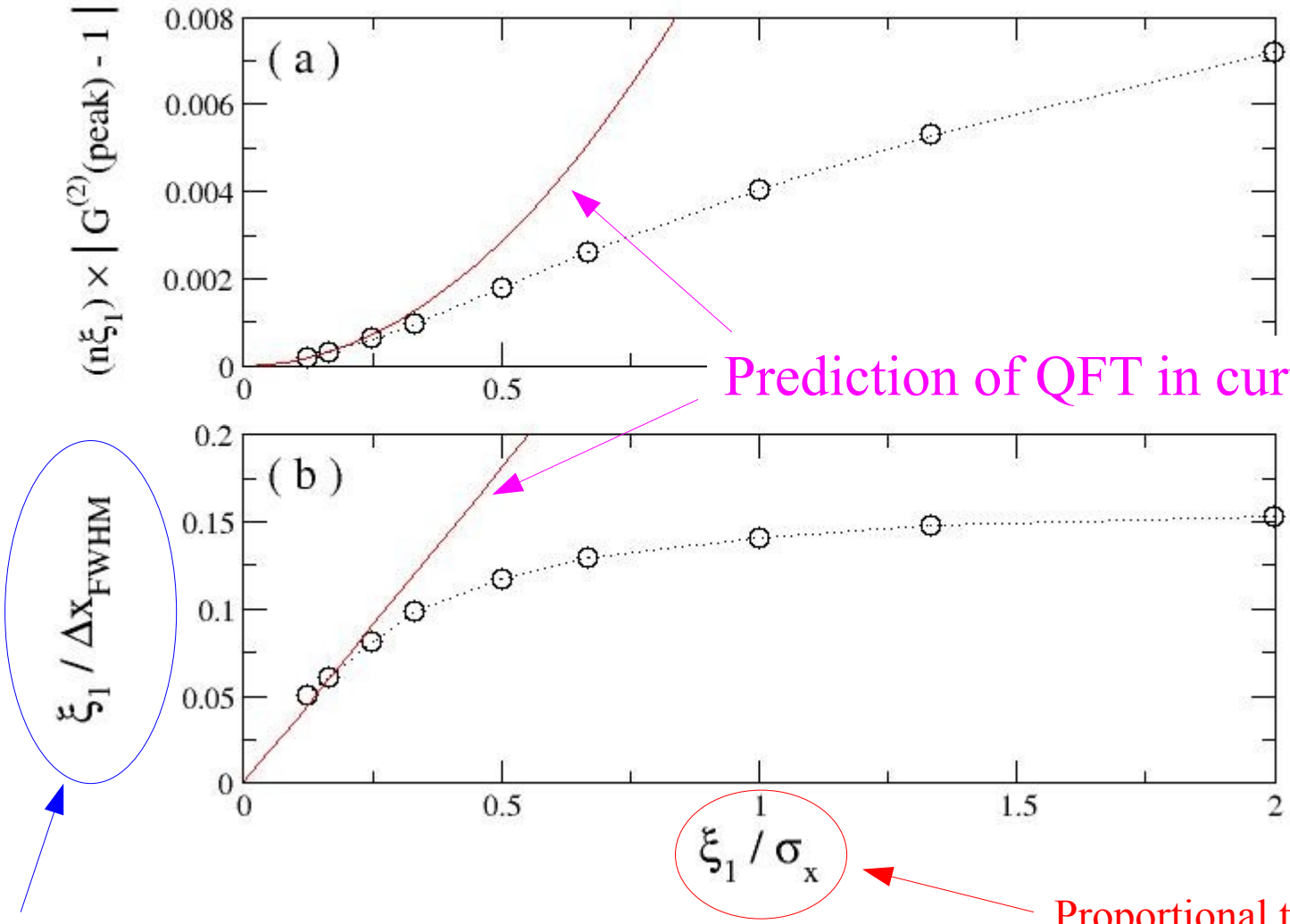
IC, S.Fagnocchi, A.Recati, R.Balbinot, A.Fabbri, New J. Phys. 10, 103001 (2008)

Quantitative analysis



Prediction of QFT in curved space-time

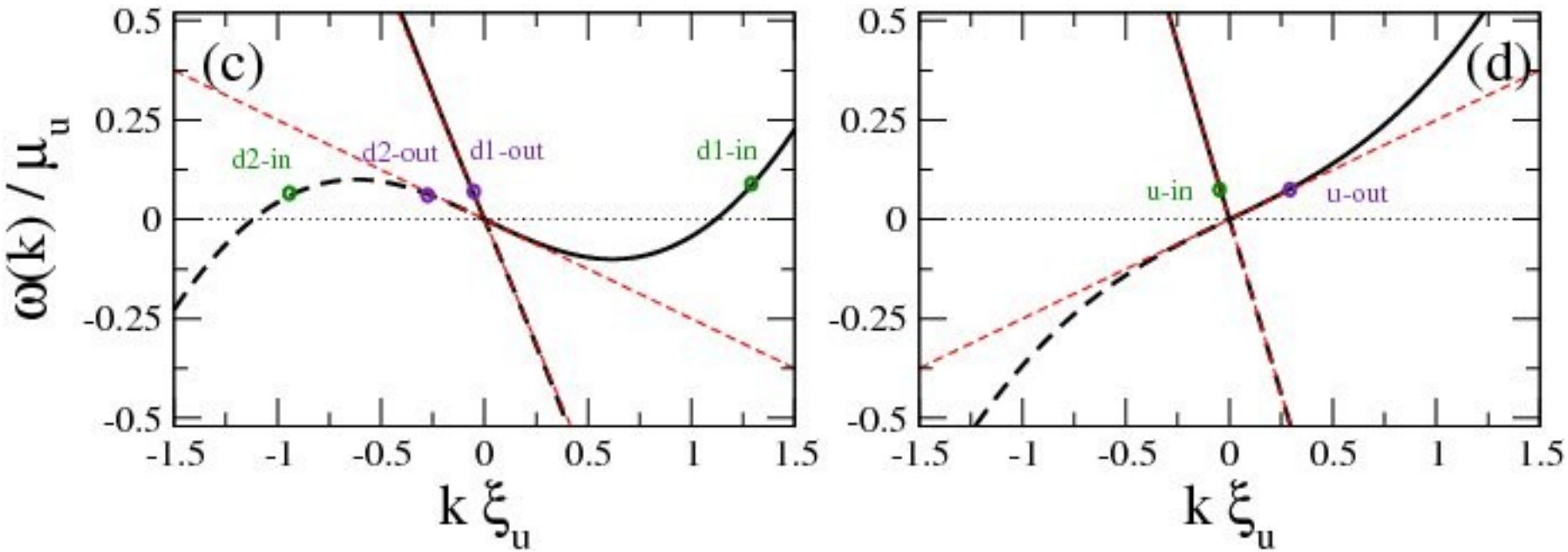
Proportional to emission temperature

Proportional to surface gravity

Curved-QFT prediction quantitatively correct in hydrodynamic limit $\xi_1 / \sigma_x \ll 1$

Significant discrepancies for strong surface gravity

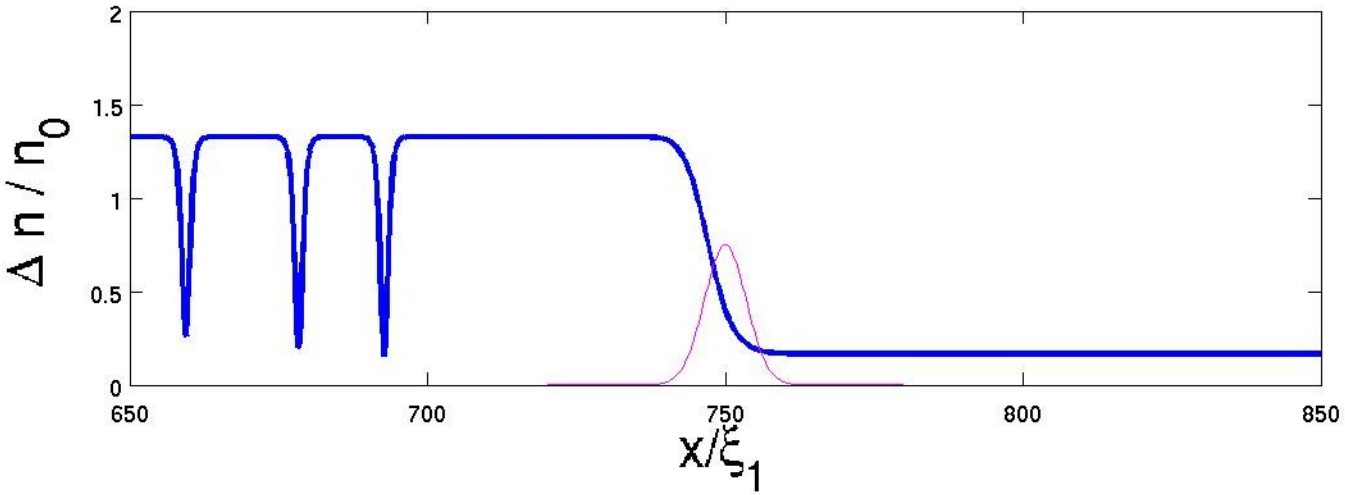
Bogoliubov dispersion: black hole case

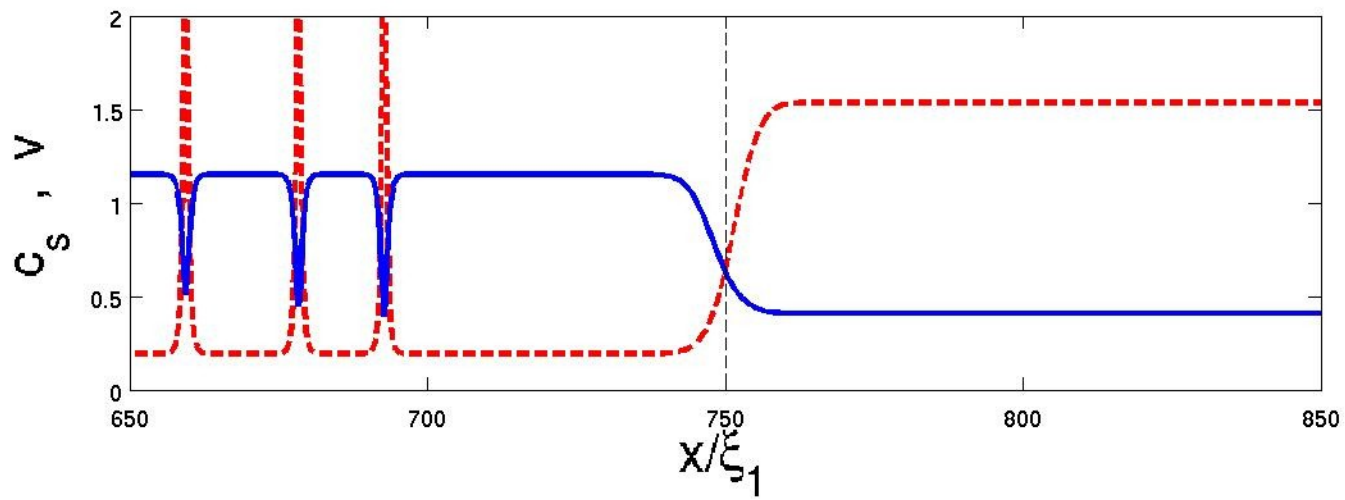


Formation of black hole at potential barrier

N. Pavloff, A. Recati, IC, in preparation (2011)

Formation of black hole at potential barrier

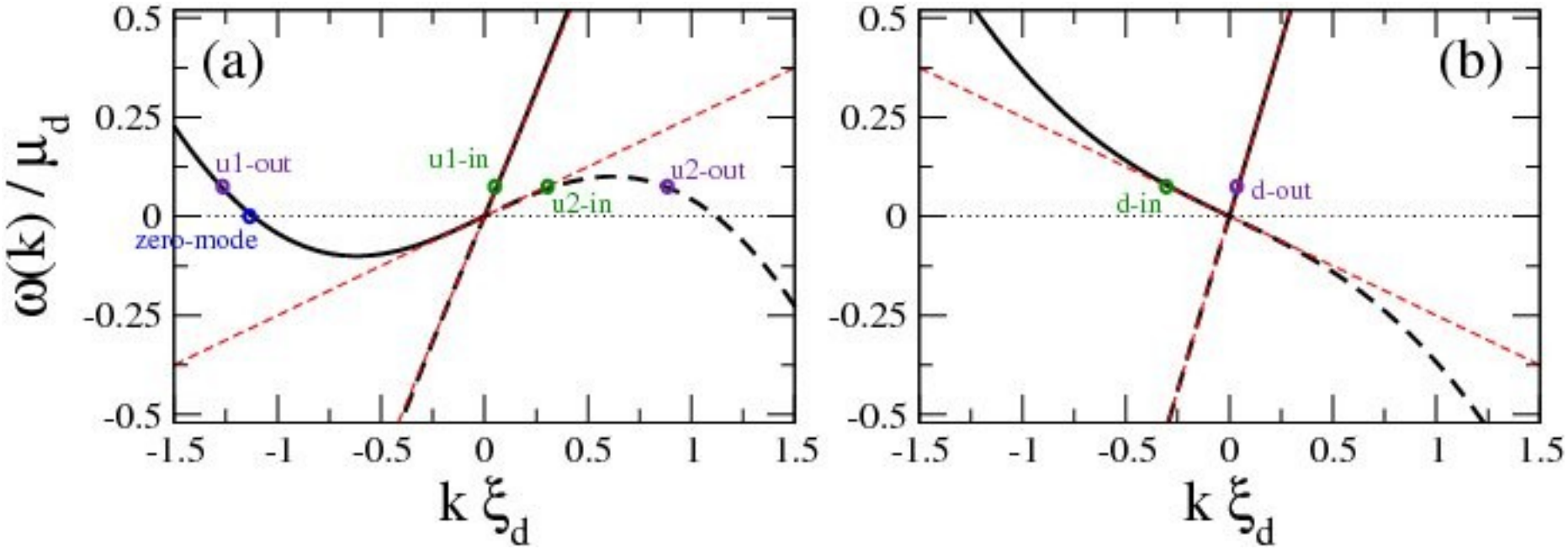




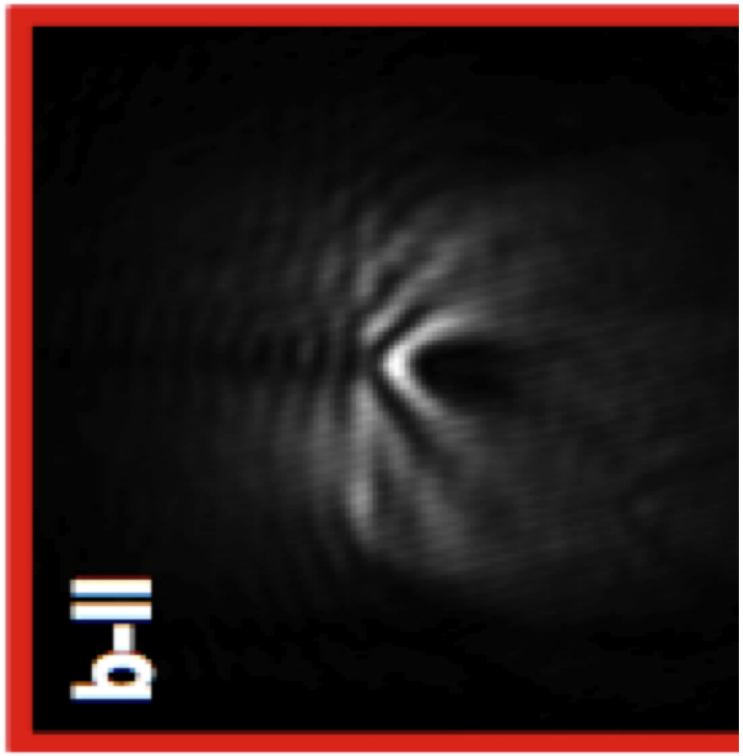
Intensity of HR can be calculated with inverse scattering techniques

N. Pavloff, A. Recati, IC, in preparation (2011)

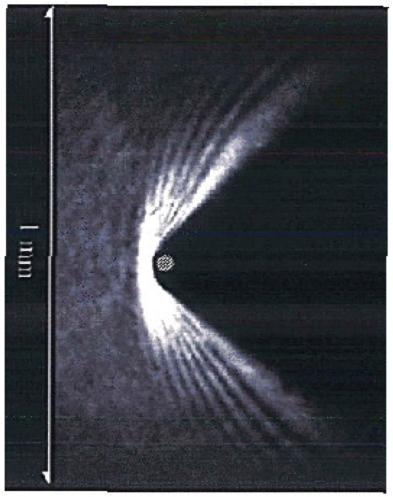
Bogoliubov dispersion: white hole case



Bogoliubov-Cerenkov wake

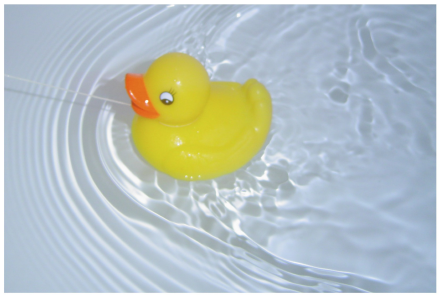


Expt with polariton BEC



Expt with atomic BEC

Expt. image from JILA
(P. Engels, E. Cornell).
Theory IC, Hu, Collins, Smerzi,
PRL **97**, 260403 (2006)



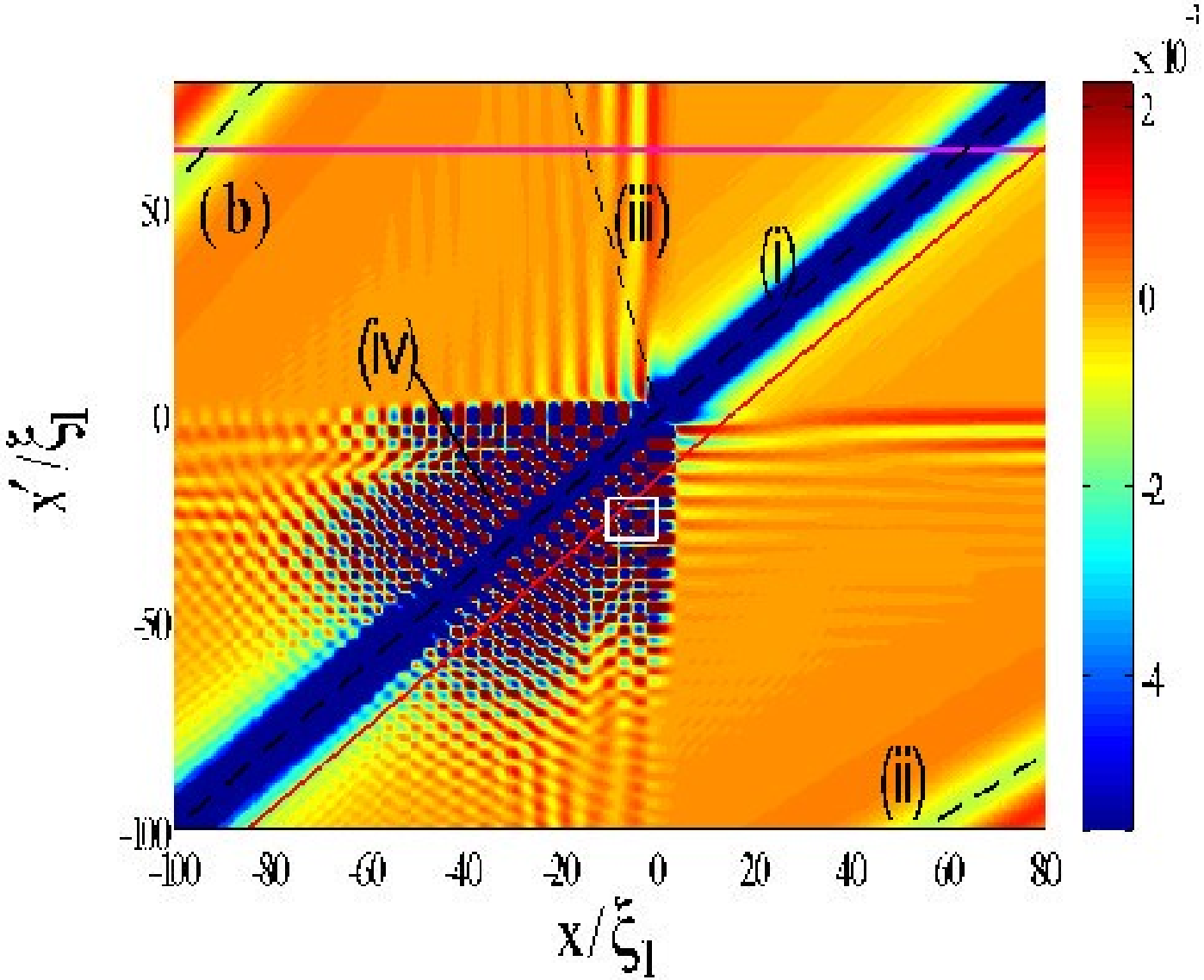
Homemade expt

Super-sonic flow hitting a defect:

- Cerenkov conical wave, aperture $\cos(\varphi) = c_s / v$
- single-particle-like parabolic precursors (zero-mode in 1D)

Exp: A.Amo, J.Lefrère, S.Pigeon, C.Adrados, C.Ciuti, IC, R. Houdré, E.Giacobino, A.Bramati, Nature Phys. 5, 805 (2009);
Th: IC and C. Ciuti, PRL **93**, 166401 (2004).

C. Mayoral, A. Recati, A. Fabbri, R. Parentani, R. Balbinot, I. Carusotto, *Acoustic white holes in flowing atomic Bose-Einstein condensates*, New J. Phys. 13, 025007 (2011)



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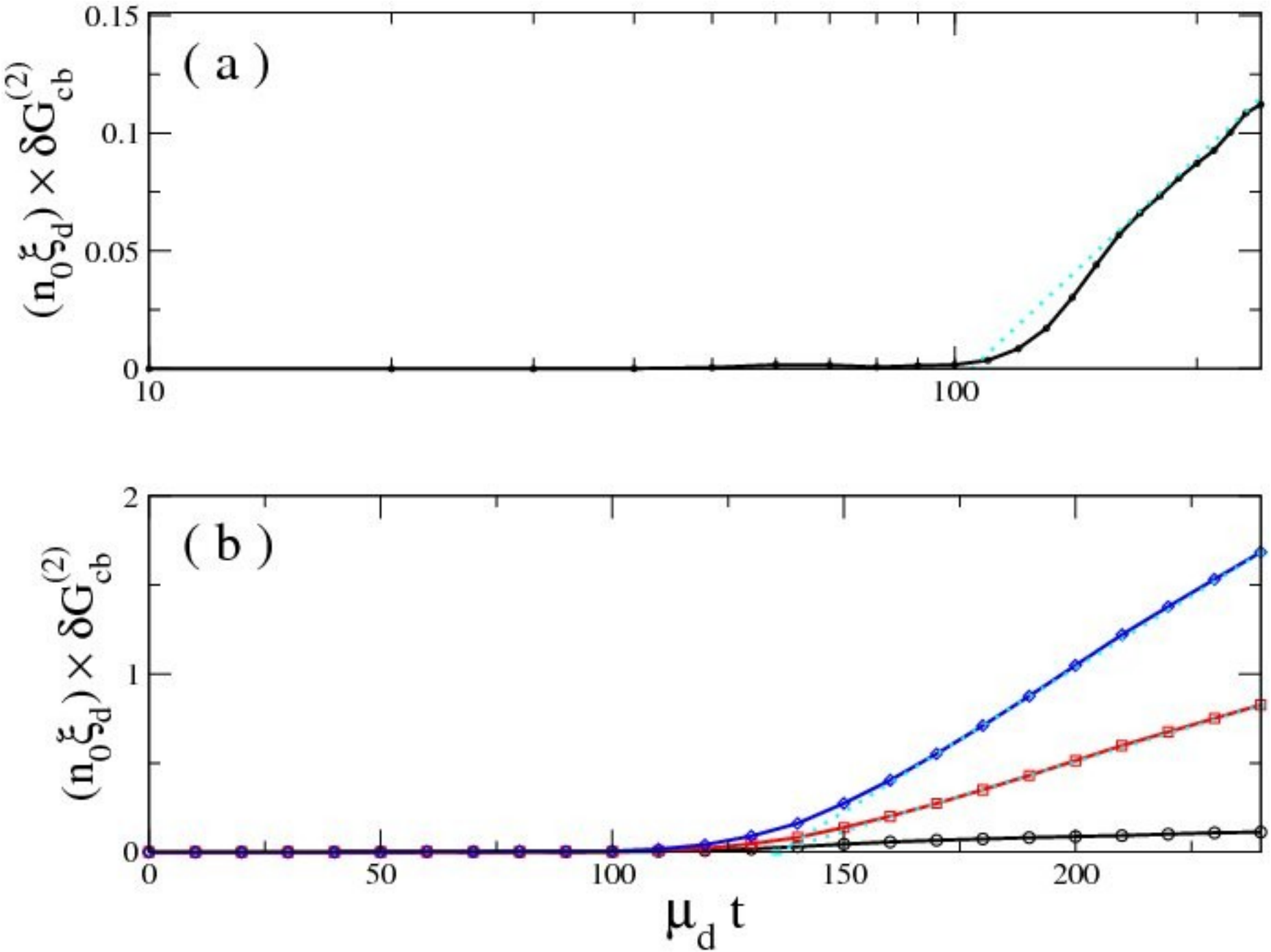

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