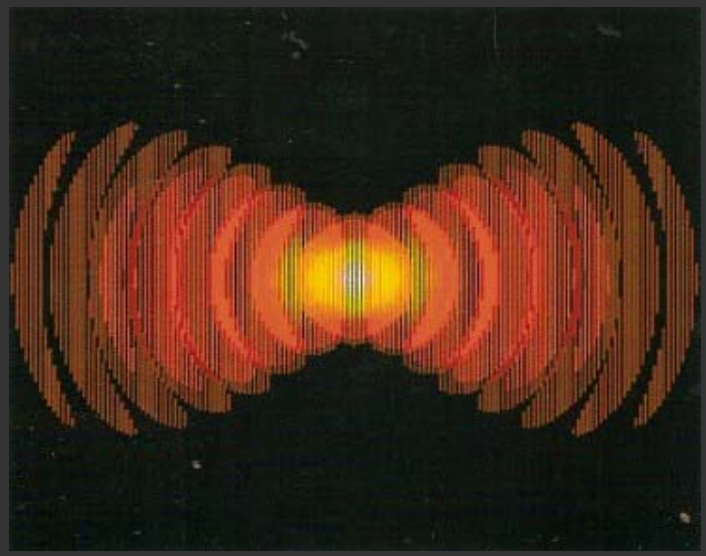
Giovanni Salesi

Università di Bergamo – Facoltà di Ingegneria
Istituto Nazionale di Fisica Nucleare – Sezione di Milano

Ricerche teoriche e sperimentali recenti dell'unità di Bergamo per l'I.S. NA41



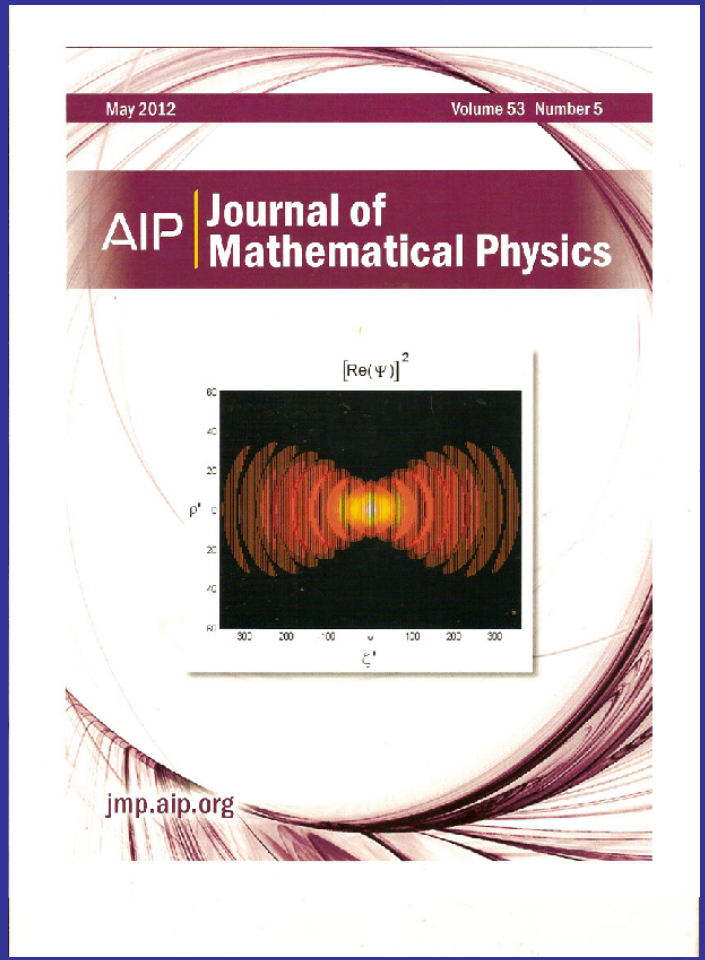
Milano, Consiglio di Sezione INFN del 24-06-2013

Principali linee di ricerca investigate negli ultimi anni

- **Struttura cinematica e teoria classica delle particelle e stringhe con spin**
- **Storia della Fisica del XX secolo (in particolare l'opera di Ettore Majorana)**
- **Nuove forme di superconduttività (mezzi a due o più fasi superconduttive)**
- **Ruolo fisico di operatori non-selfadjoint e quasi-hermitiani**
- **Tempi di tunnelling e effetto-Hartman per particelle e fotoni**
- **Soluzioni localizzate, frozen, non-diffracting, delle equazioni d'onda**
- **Violazioni della relatività ad altissime energie e spaziotempo con metrica energy-dependent (conseguenze osservabili in fisica delle particelle, astrofisica e cosmologia)**
- **Nuovi fenomeni microscopici nei fluidi viscosi (*pipe-effect*, fotoluminescenza ritardata)**
- **Studio dell'entropia e dell'ergodicità in catene di oscillatori accoppiati non-linearmente**

Soluzioni localizzate dell'equazione d'onda (in particolare le *frozen waves*)

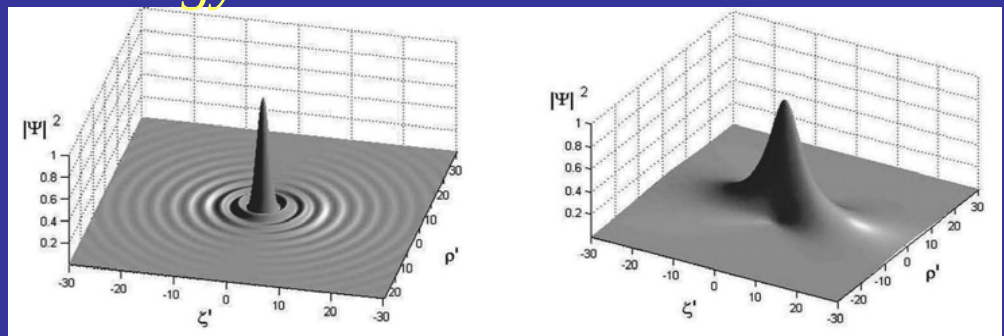
Researches on "Localized Solutions" to the linear wave equations, looking also for analogous, non-diffracting solutions to equations more interesting for particle physics (and for gravitational waves)

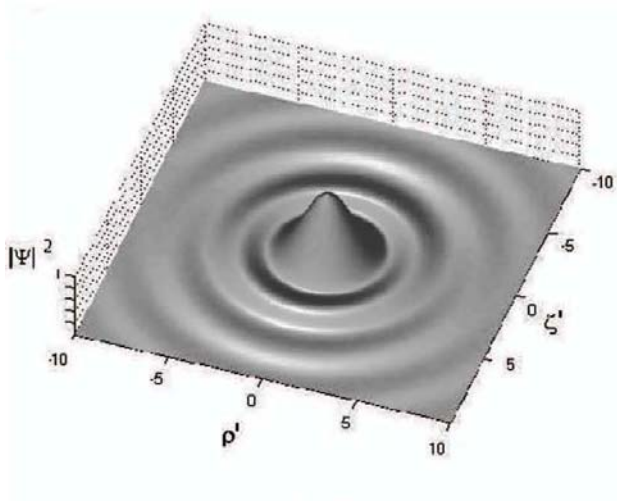


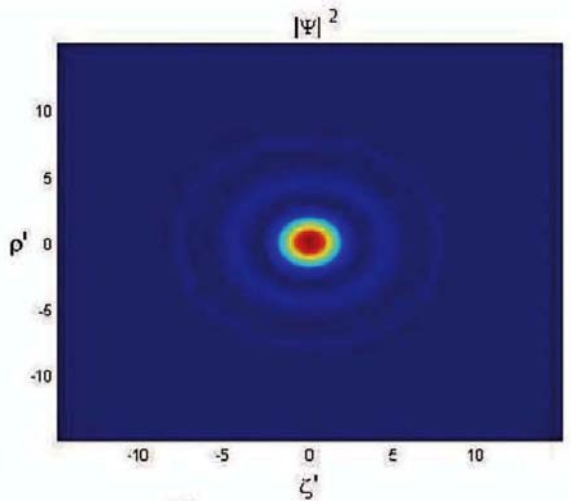
❖ **Recami et al., *Soliton-like solutions to the ordinary Schrödinger equation within standard QM*, J. Math. Phys. 53 (2012) 052102**

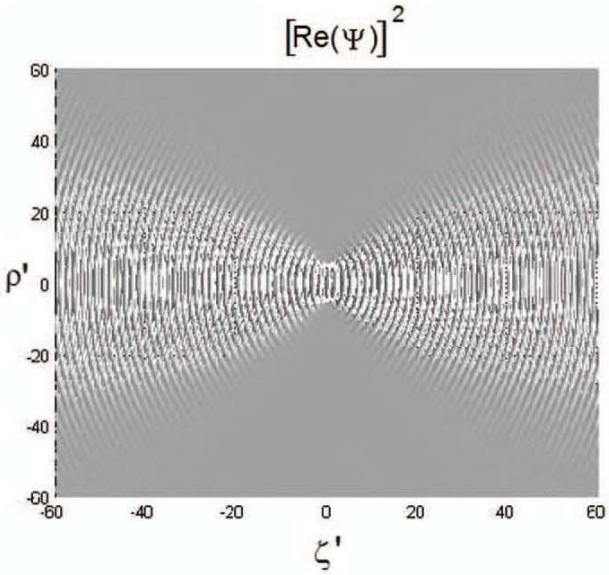
In recent times attention has been paid to the fact that (linear) wave equations admit of "soliton-like" solutions, known as localized waves or non-diffracting waves, which propagate without distortion in one direction. Such localized solutions exist also for K-G or Dirac equations and are suitable, more than gaussian's, for describing elementary particle motion

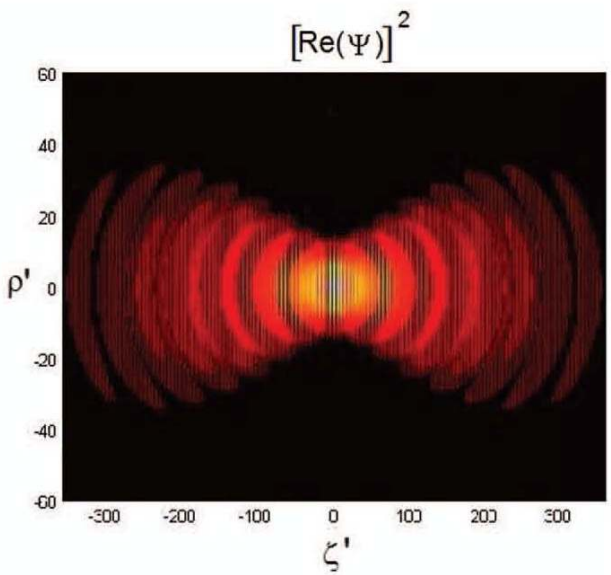
In that paper we show that, *mutatis mutandis*, localized solutions exist even for the ordinary (linear) Schroedinger equation within standard quantum mechanics; and we obtain both approximate and exact solutions, also setting forth for them particular examples. In the ideal case such solutions (even if localized and "decaying") are not square-integrable, as well as plane or spherical waves: we show therefore how to obtain *finite-energy solutions*




$|\Psi|^2$
-10
-5
0
5
10
ρ'
ζ'


$|\Psi|^2$
10
5
0
-5
-10
ρ'
-10
-5
0
5
10
ζ'


$[Re(\Psi)]^2$
60
40
20
0
-20
-40
-60
ρ'
-60
-40
-20
0
20
40
60
ζ'


$[Re(\Psi)]^2$
60
40
20
0
-20
-40
-60
ρ'
-300
-200
-100
0
100
200
300
ζ'

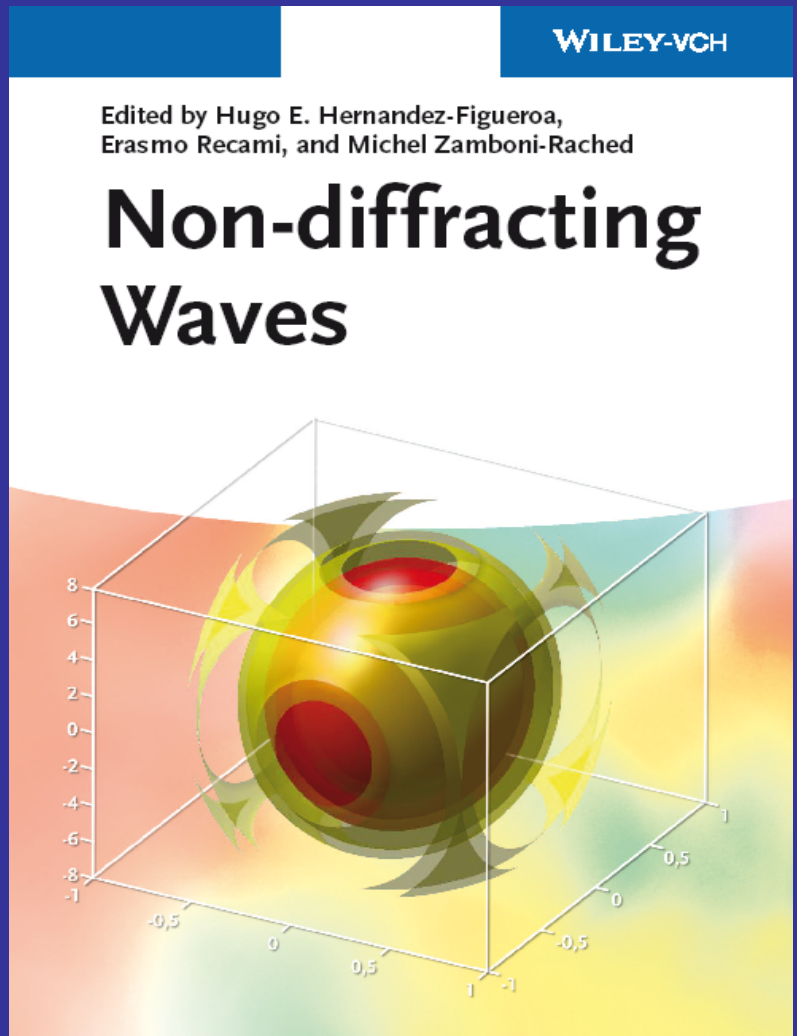
We have invented a method based on appropriate superpositions of Bessel–Gauss beams, which in the Fresnel regime is able to describe in analytic form the 3D evolution of important waves (Bessel beams, plane waves, Gaussian beams, and Bessel–Gauss beams) when truncated by finite apertures (i.e. emitted by finite antennas)

This allowed, and allows, finding out and plot in a few seconds solutions, which required days (or months) of numeric simulations

The method works in electromagnetism (optics, microwaves) as well as in acoustics

- **Recami et al., *Simple and effective method for the analytic description of important optical beams when truncated by finite apertures*, Applied Optics 51 (2012) 3370**

after the volume *Localized Waves*, J.Wiley, 2008, co-edited by Recami with H.E.H.Figueroa and M.Z.Rached, a second volume has been accepted (2012) by the J.Wiley of Berlin, with the title *Non-Diffracting Waves*, ed. by Recami and the pervious co-editors (expected to appear in 2013)



❖ **Recami et al., *Producing Acoustic Frozen Waves: Simulated experiments*, accepted by the (ISI) journal IEEE Trans. Ultrason. Ferroel. Freq. Control**

We have studied and applied the most important Localized Waves: namely, on those *with zero group-velocity* (that is, with a static envelope)

We called such waves *Frozen Waves* which are now realizing in *Acoustics*, bearing in mind some remarkable medical applications, like the destruction of tumour cells without affecting the foregoing or successive tissues

Recently a laboratory at the UFABC of Sao Paulo of Brazil produced them in Optics, experimentally realizing “light at rest” (cf. Optics Letters 2012 paper)

We have investigated the fundamental differences existing between *X*-shaped Localized Waves and Cherenkov radiation, publishing the paper

- **Recami et al., *Further comments on Cherenkov versus X-waves”*, Journal of the Optical Society of America A 29 (2012) 2536**

In this article there have been also deepened and clarified some aspects of the so-called “extended special relativity” relevant for such a question

We have applied previous results of our researches on Tunneling effect in constructing a purely quantum model of Big-Bang

- **Recami et al., *A Fully quantum model of Big-Bang*, appeared as a chapter of the book Theoretical Concepts in Quantum Mechanics (Intech, 2012, pp.341-382)**

Nuove forme di superconduttività (mezzi a due o più fasi superconduttive)

- G. Salesi et al., *Superconductors with two Critical Temperatures*, Physica C451 (2007) 86
- G. Salesi et al., *Second Discontinuity in the Specific Heat of Two-Phase Superconductors*, Physica C467 (2007) 4
- G. Salesi et al., *Magnetic Properties of Two-Phase Superconductors*, Physica C468 (2008) 883
- G. Salesi et al., *A Generalization of the Ginzburg-Landau Theory to p-Wave Superconductors*, Mod.Phys.Lett. B22 (2008) 1709
- G. Salesi et al., *Describing Sr_2RuO_4 Superconductivity in a Generalized Ginzburg--Landau Theory*, Phys.Lett. A373 (2009) 2385
- G. Salesi et al., *Dependence of the Critical Temperature on the Higgs Field Parametrization*, J.Phys. G36 (2009) 115001

G. Salesi et al., *Dependence of the Critical Temperature on the Higgs Field Parametrization*, J.Phys. G36 (2009) 115001

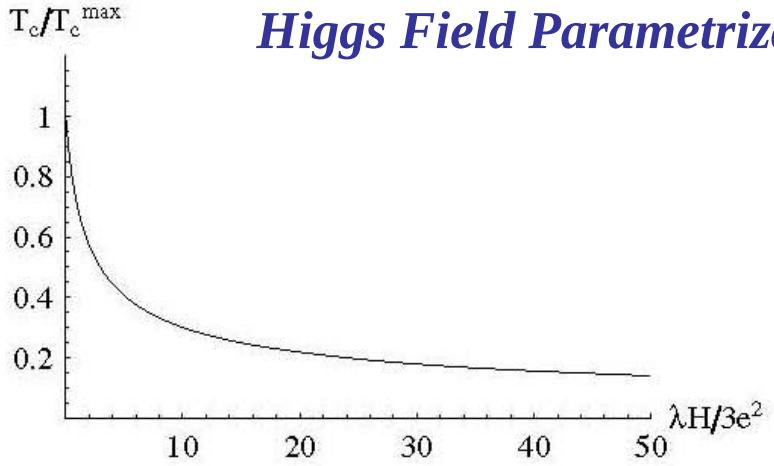


Figure 1. Critical temperature versus the 'representation factor' *H*.

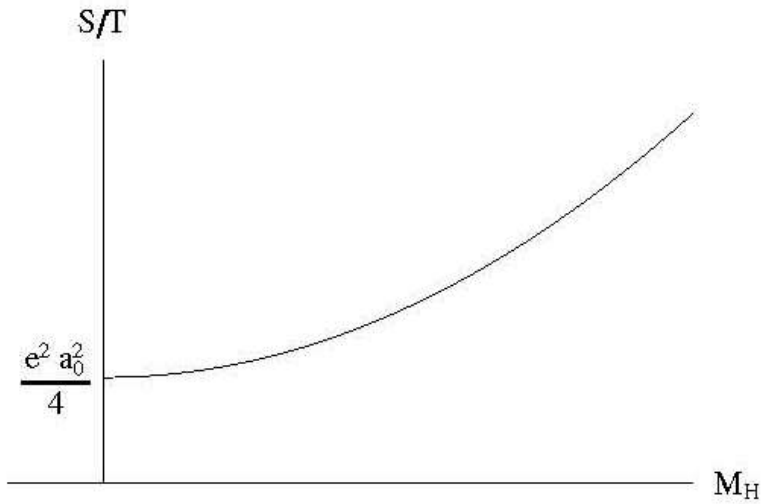


Figure 2. Entropy versus the Higgs mass, for a given temperature.

Violazioni della relatività ad altissime energie e spaziotempo con metrica energy-dependent

Prime applicazioni alla fisica delle particelle, all'astrofisica e cosmologia di leggi di dispersione Lorentz-violating

- **G. Salesi et al., *Laboratory Bounds on Lorentz Symmetry Violation in Low Energy Neutrino Physics*, Mod.Phys.Lett. A21 (2006) 349**

- **G. Salesi et al., *Baryon Asymmetry in the Universe Resulting from Lorentz Violations*, Europhys.Lett. 74 (2006) 747**

- **G. Salesi et al., *CPT-Violating Neutrino Oscillations*, Mod.Phys.Lett. A25, (2010) 597**

We have recently put forward a Lorentz-violating energy-momentum dispersion relation entailing an exact momentum cut-off

In G. Salesi et al., *Black Hole Evaporation within a Momentum-Dependent Metric,* Phys.Rev D79 (2009) 104009 we investigate the black hole thermodynamics in a ‘‘deformed’’ relativity framework where the energy-momentum dispersion law is Lorentz-violating and the Schwarzchild-like metric is momentum-dependent with a Planckian cutoff. We obtain net deviations of the basic thermodynamical quantities from the Hawking-Bekenstein predictions: actually, the black hole evaporation is expected to quit at a nonzero critical mass value (of the order of the Planck mass), leaving a zero temperature remnant, and avoiding a spacetime singularity

In G. Salesi et al., *Black Hole Dynamical Evolution in a Lorentz-Violating Spacetime,* Phys.Rev. D83 (2011) 084043, considering the black hole dynamical evolution in the framework of a Lorentz-violating spacetime large deviations from the Hawking-Bekenstein predictions are obtained, depending on the values of the Lorentz-violating parameter introduced. For large Lorentz violations, most of the black hole evaporation takes place in the initial stage, which is then followed by a stationary stage where the mass does not change appreciably. Furthermore, for the final stage of evolution, our model predicts a sweet slow death of the black hole in contrast with the violent final explosion predicted by the standard theory

In 2012 (G. Salesi et al., *Lorentz-violating dynamics in the pre-Planckian Universe,* Phys. Rev. D85 (2012) 063502)

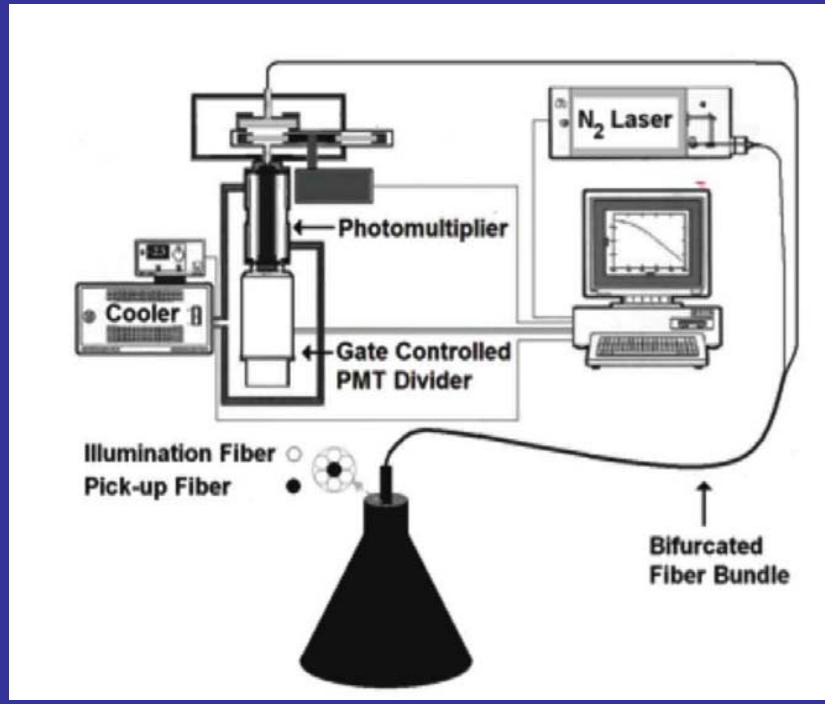
we have studied the Lorentz violation effects on early Universe and pre-Planckian cosmological radiation

In particular, we have predicted an effective infinite speed of light soon after the Big Bang instant, leading to a possible solution of the horizon and flatness problems without recourse to inflation, cosmological scalar fields or other ad hoc energy sources

Presently, some goals are: calculating the dynamical evolution of the universe considering also the momentum dependence in a Lorentz-violating FRW metric; finding the modified Lorentz transformations in DSR for the spacetime coordinates by investigating the deformed Poincaré algebra

Nuovi fenomeni microscopici nei fluidi viscosi (*pipe-effect, fotoluminescenza ritardata*)

At Catania LNS-INFN we have recently started an experimental study on delayed luminescence (DL) in “low-density” water domains for TEOS (ortosilicato tetraetile) solutions prepared at chemical laboratories of Facoltà di Ingegneria of Bergamo University



We have detected, in different measurement campaigns, net DL signals depending on the water temperature and on the inorganic thickener concentration. The DL events have been analyzed in both space and time domains

❖ **G. Salesi et al., *A new dielectric effect in viscous liquids* Eur. Phys. J.Appl. Phys. 62, 31103p1 (2013)**



Abstract. An accurate experimental and theoretical study has been performed about a phenomenon, not previously reported in the literature, occurring in highly viscous liquids: the formation of a definite pipe structure induced by the passage of a heavy body, this structure lasting for quite a long time. A very rich phenomenology (including mechanical, optical and structural effects) associated with the formation of the pipe has been observed in different liquids. Actually, the peculiar dynamical evolution of that structure does not appear as a trivial manifestation of standard relaxation or spurious effects. In particular, we have revealed different time scales during the evolution of the pipe and a non-monotonous decrease of the persistence time with decreasing viscosity (with the appearance of at least two different maxima). We put forward a microscopic model, consistent with the experimental data, where the pipe behaves as a "dielectric shell" whose time evolution is described through a simple thermodynamical approach, predicting several properties effectively observed.

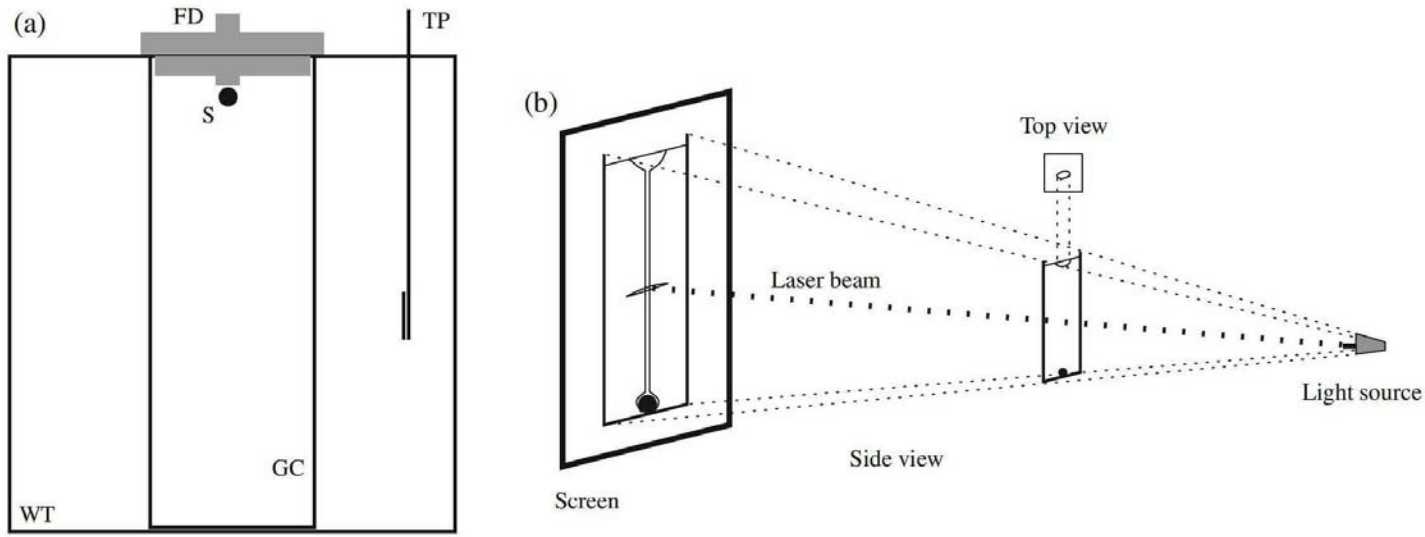


Fig. 1. (a) Experimental apparatus employed to produce and observe the pipe effect in glycerol: WT, water thermostat; GC, glycerol container (graduated tube); FD, falling device; S, steel sphere; TP, temperature probe; (b) a schematic view of the experimental arrangement for studying the optical properties of the pipes formed in glycerol.

Studio dell'entropia e dell'ergodicità in catene di oscillatori accoppiati non-linearmente

A partire dal celebre esperimento computazionale di *Fermi, Pasta e Ulam*, i pendoli accoppiati sono stati associati allo studio dei fenomeni di termalizzazione spontanea e delle ricorrenze ergodiche dei sistemi a molti corpi con interazioni interne non-lineari, anche nell'ottica di comprendere più a fondo la natura statistica dell'equipartizione dell'energia e del secondo principio della termodinamica

Nella ricerca monitoriamo nel tempo e nello spazio (tramite un sistema ottico automatizzato di videotracking) i moti singoli e collettivi che si svolgono in una catena di 24 pendoli accoppiati, sita presso i nuovi laboratori di Ingegneria, al variare delle condizioni iniziali (energia del primo oscillatore, lunghezza pendolare, intensità dell'accoppiamento, anarmonicità)

I primi risultati indicano, a seconda dei casi, termalizzazione ed ergodicità, ma anche ricorrenze di Poincaré, caos, solitoni, ILMs (intrinsic localized modes)