[*C1*. S. Aubry] About the Origin of Sonoluminescence

Some liquids (typically water), submitted to intense ultrasounds (at typically 40 kHz), may emit broadband light (sonoluminescence) over frequencies ranging from IR to UV. It has been proven experimentally that sonoluminescence is generated by stable spherical microbubbles (of the order of μm) of some insoluble gas (typically rare gas). The radius of those bubbles oscillates at the frequency of the driving ultrasound. When the pressure amplitude of the ultrasound field becomes larger than a certain threshold (typically 1B), the gas in the bubble reaches its minimum Van der Waals volume and there is a radial impact of the fluid onto the core of the bubble. This situation occurs at radial bubble velocities comparable to the sound velocity in the liquid. During this sharp impact which lasts few 100 ps, the flash of light which produces sonoluminescence, is emitted. The most frequent interpretation of this phenomena is that the energy of the shock wave generated at the impact focuses and diverges at the bubble center (in quasilinear theories) which should generate a plasma at a very high temperature emitting the light flash. It was even argued that nuclear fusion could be generated in that way. However, this interpretation is ruled out by some crucial experiments for example by the fact that near threshold, sonoluminsecence becomes dim with a spectrum shifted toward IR which moreover is much more pronounced with deuterated water. Up to now the physical origin of this pheneomena remains an enigm.
We suggest a new interpretation for this phenomena. Shockwaves which are generated by quasisupersonic impacts becomes tremendously nonlinear. We prove in that conditions with rigourous arguments only based on mass conservation and the existence of a Van der Waals minimum volume that energy focusing cannot occur at the bubble center. A compacted sphere appears right after the impact which includes the compacted gas of the bubble but also and mostly a part of the surrounding liquid. The pressure and temperature inside becomes very high but remains spatially rather uniform. The radius of this compacted sphere expands up to few minimum bubble radius while its pressure and temperature simultaneously drops very fast. Next the pressure profile in the liquid continues to evolve but as a standard quasi linear pressure pulse which radially propagates and decays. It is also proven that the sound velocity in the liquid of that highly compacted sphere, is enhenced by a factor λ near unity at weak impacts but which suddenly increases as soon the impact becomes close to supersonic. It may easily reach one or several order of magnitudes in the experimental conditions. Thus beyond a certain threshold, this Grüneisen coefficient λ becomes large, so that the frequency spectrum of the thermal radiation of the compacted liquid and gas is strongly dilated from IR toward UV while its temperature is (adiabatically) increased by the same factor λ (which correspond to a power of the thermal radiation increased by λ^4). The sonoluminescent light flash is thus due to the intense thermal radiation of this compacted sphere (which is mostly composed of the liquid surrounding the bubble) during the short time of its existence.

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[*C2*. F. Onufrieva] Magnetic and Electronic properties of the High-Tc Cuprates: from electron- to hole- doping.

We have shown that a basic difference between electron- and hole- doped cuprates is their proximity to two different topological quantum critical points (QCP's), one related to saddle point electrons and relevant for hole-doped Cuprates and the other related to nodal electrons and relevant for electron-doped cuprates. This has consequences for both magnetic and electronic properties.

1. Spin dynamics
We have shown [1] that the striking features observed recently in the electron-doped cuprates (neutrons), the extremely narrow q width and very low spin gap, are consequences of the proximity to the "nodal" quantum critical point while the resonance peak that is a remarkable property of the hole-doped cuprates (also observed by neutrons) is a consequence of the proximity to the "saddle point" quantum critical point.

2. Electronic properties:
We have shown [2] that the presence of these QCP's imposes srtong constraints on electronic properties in the cuprates. One of the consequences is the existence of the electron pseudogap of density wave origin, large pseudogap, that increases towards low doping from both sides, electron- and hole- doping. The qualitative behaviour and even absolute values of the pseudogap are in a good agreement with experiment (ARPES, optical conductivity etc.). Another effect is the existence at low doping of a second pseudogap, one order of magnitude smaller (at T=0 it becomes a true gap). This small gap also increases towards zero doping and could explain the recent ARPES observation of the small gap observed for both electron and hole doping in the whole Brillouin zone. The most interesting feature is the existence at low doping of a specific insulating state different from the Mott-Hubbard (MH) insulator. It is characterized by a small chemical potential jump (much smaller than in the MH insulator), this feature is close to that observed experimentally.

[Collaboration: F.Onufrieva et P.Pfeuty, LLB]

[1] F.Onufrieva and P.Pfeuty Phys.Rev.Lett. 92 247003 (2004).
[2]F.Onufrieva and P.Pfeuty Phys.Rev.Lett. 95 207003 (2005).