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Editorial

Liquid and amorphous metals: Current trends and future perspectives

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Editorial

Liquid and amorphous metals are an outstanding example of systems combining great relevance in both industrial applications and basic science. They find broad technological application, ranging from the production of industrial coatings (walls of refinery cokers, drill pipes for oil drilling) to medical equipment (reconstructive devices, surgical blades) or high-performance sporting goods. Most metallic materials, indeed, need to be refined in the molten state before being manufactured.

Liquid metals, in particular the monoatomic ones, have long been recognized as the prototype of simple liquids, in the sense that they encompass most of the physical properties of real fluids without the complications which may be present in a particular system. Until the sixties the understanding of the physical properties of liquid metals proceeded rather slowly. It was John Ziman, indeed, who first developed a theory for the electron transport in liquid metals in 1961, and subsequently several experimental and theoretical studies were presented at the first Liquid Metals International Conference held in Brookhaven in 1966 (see, for example, refs. [1–3]).

From the experimental point of view, the 1950s saw major efforts related to the development of neutron scattering facilities, which constitute a unique probe in accessing the microscopic structure and dynamics in condensed matter and, in particular, in the liquid and amorphous state. A further experimental breakthrough, however, has happened in the last twenty years when X-rays generated by synchrotron radiation facilities could be used as a probe for structure and dynamics in frequency and wavelength regions similar to those explored by neutrons.

Concerning the nature of the dynamical structure in liquid and amorphous metals, in the last two decades many theoretical and experimental groups have switched their studies to researching effects due to non-hydrodynamic processes in liquids, i.e. collective processes which cannot be predicted by ordinary hydrodynamics. Examples of such non-hydrodynamic propagating excitations are shear waves, the famous "fast sound" [4] in binary liquids with disparate masses, or charge waves in ionic melts [5], while the most obvious non-hydrodynamic relaxation process is structural

relaxation. To date, there is no general agreement on the dispersion law and damping of non-hydrodynamic processes or their effect on propagating sound excitations on different time and length scales, and the situation in extreme thermodynamic conditions relevant to the earth's interior and geophysical science is even less clear. Thanks to the advent of relatively fast structural probes within X-ray-related techniques, a number of experimental works have been carried out to study liquid metals out of their thermodynamic equilibrium: the issue of the icosahedral ordering in simple undercooled liquid metals has been widely investigated and it still stimulates further studies in more complex metallic systems. Within this context, the search for density-driven polyamorphism in liquid metallic and quasi-metallic systems has proved to be particularly fertile in the last decade or so [6].

The main idea of this special issue is to exploit the spark of the LAM14 Conference [7] to bring together experimental, theoretical and simulation groups in order to present the state of the art and the future challenges in experimental techniques, advanced analysis methodologies, recently elaborated theoretical approaches and modern simulation techniques.

This issue of the European Physical Journal contains 15 selected and fully reviewed contributions. Topics covered by this issue include: Modern theory and calculations for liquid metals (W. Schirmacher, L.E. Gonzalez et al., L. Calderin et al., M. Celino, M. Colakogullari et al., F. Shimojo et al., T. Bryk); Advanced X-ray studies of liquid metals (Hosokawa et al., Matsuda et al., P.S. Pershan); Science in extreme conditions, relevant for the earth's interior and planetary thermodynamics (W. Nellis, I. Egry et al., L. Hennet et al., M. Inui et al.); Ultrafast techniques applied to metallic-like disordered systems (Yao et al.)

It is our hope that this special issue will help in exchanging information on recent progress in experimental, numerical and theoretical approaches. A careful, comprehensive analysis of the reported contributions should provide a basis for new studies in this field and set the stage for the next generation of researchers.

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The guest editors,
Tullio Scopigno, Simone De Panfilis and Andrea Di Cicco

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