Homogeneous melting dynamics of bulk ice

Samuele Fanetti[1,2*], Naomi Falsini[1] ,Paolo Bartolini[1], Margherita Citroni[1], Andrea Lapini[1,3], Andrea Taschin[1,4], Roberto Bini[1,2,5]

[1]*LENS, European Laboratory for Non-linear Spectroscopy, Via N. Carrara 1, 50019 Sesto Fiorentino, Firenze, Italy*

[2]*ICCOM, Istituto di Chimica dei Composti OrganoMetallici, Via Madonna del Piano 10, 50019 Sesto Fiorentino, Firenze, Italy*

[3]*INRIM, Istituto Nazionale di Ricerca Metrologica, Strada delle Cacce 91, 10135 Torino, ITALY*

[4]*ENEA, Centro Ricerche Frascati, Via E. Fermi 45, 00044 Frascati, Roma ITALY*

[5]*Dipartimento di Chimica "Ugo Schiff", Universitá di Firenze, Via della Lastruccia 3, 50019 Sesto Fiorentino, Italy*

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*e-mail: fanetti@lens.unifi.it

The homogeneous melting of a crystal is a complex process that involves the formation of transient states at a temperature higher than the thermodynamic melting point[1]. The characteristics of the transient states and the duration time they exist are peculiar of the type of crystal (molecular, covalent, hydrogen-bonded, ionic, metallic, etc.) and they are far to be well understood even for simple systems[2].

We conceived a new kind of time resolved experiment to study, by means of transient infrared spectroscopy with high temporal resolution, the entire dynamics of the superheating and melting process, ranging from few tens of picoseconds, up to the millisecond time regime, for samples compressed in sapphire anvil cells.

We characterized the time constant associated to homogeneous melting of a molecular and H-bonded crystal of paramount importance: water ice (Ih). We found an incredibly long-lasting metastable superheated state in which ice persists for tens of nanoseconds at a temperature higher than the thermodynamic melting point, without undergoing to melt.

This is preliminary to the study of the melting dynamics of the high pressure phases of water (III, V, VI, VII) and binary systems like clathrate hydrates, which aims to understand the effect of density and molecular arrangement on the characteristic lifetimes of the melting itself, and the metastable transient states involved in the melting process.

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