# Soft modes in hard sphere glasses

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Glassy materials present very different transport, rheological and vibrational characteristics from crystalline solids. In spite of being ubiquitous in nature and technology, the microscopic mechanisms of the glass transition and the explanation of the anomalous properties of these materials challenge our understanding. We used the hard spheres to study the properties of glasses and its dynamics. Recent works, starting from the idea that weakly-connected solids live close to the limit of mechanic instability, show that this implies the existence of low-frequency vibrational modes, the Boson Peak. Such anomalous modes, which differ markedly from the usual extended plane waves, are characterized by a length scale that diverges at the maximum random packing.

In this presentation, I will show our theoretical and numerical study about the origin of the microscopic rigidity in a hard sphere glass. By deriving an effective potential for the system and, by computing their vibrational modes, we derived a rigidity criterion for hard spheres. The rigidity of the glass phase requires the formation of a contact network respecting a balance between the mean coordination number of the spheres and the pressure. We have shown that this balance occurs in such a way that the rigidity is established only marginally, which implies the existence of an excess of anomalous modes. Such modes dominate the microscopic and structural relaxation in the glass phase as well as in in the super-cooled liquid.