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Homogeneous nucleation of solid, liquid and glass phases close to revolution

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The classical nucleation equation fails to predict the glass phases, the liquid-to-liquid phase transitions (LLPT), Lindemann's constant, the presence of intrinsic growth nuclei above T_m inducing magnetic texturing by cooling magnetic melts in high magnetic fields, and the first-order glass transitions of liquid helium under pressure. These problems are solved adding in (1) an enthalpy saving $\varepsilon \times \Delta H_m$ associated with the formation of spherical growth nuclei (super clusters) having the same melting temperature Tm and melting enthalpy ΔH_m per mole whatever their radius R is: $\Delta G = \frac{4\pi R^3}{3}\Delta H_m \times (\theta - \varepsilon) + 4\pi R^2 (1+\varepsilon)\sigma_1 \Delta H_m$ (1 where $\varepsilon(\theta) = \varepsilon 0(1-\theta^2 x\ \theta o^{-2})$ is a numerical coefficient equal to εls or εgs or $\Delta\varepsilon_{1g}=(\varepsilon_{1s}-\varepsilon_{gs})$ with the indexes l for liquid, s for solid and g for glass phases, $\theta = (T-T_m)/T_m$ and θ_0 is θ_{0l} or θ_{0g}. The glass transition is viewed as a LLPT from Phase 1 above Tg to Phase 2 below Tg. $\varepsilon_{ls} \times \Delta H_m$ is reduced at the glass transition with εls replaced by εgs and θ_{0m} by θ_{og}, ε_{ls} and ε_{gs} being the enthalpy saving maximum coefficients associated with the homogeneous nucleation of nuclei inducing crystallization. The enthalpy change at Tg giving rise to the glass phase obeys (1) with ε replaced by εlg. All thermodynamic properties are calculated when Tg, εls=εls0 at Tm and θ_{0l} are known. Phase 3 is relaxing in Phase 2. An enthalpy excess, due to quenching the melt or to vapor deposition, can induce sharp transitions to Phase 3. Two homogeneous nucleation temperatures θ =ε above Tm and θ =(ε-2)/3 below Tm are expected minimizing the surface energy. Values of ε have been obtained in pure liquid elements, strong and fragile glass-forming melts. In pure liquid elements, the smallest value $\varepsilon_{ls}0=0.217$ leads to Lindemann's constant equal to 0.103 at T_m. $\Delta\varepsilon_{lg}$, ε_{ls} and ε_{gs} are used to predict LLPT between phase 1 and phase 2 above and below T_m even in water.

Biography

Robert F Tournier was Research Director at CNRS Grenoble in 2000. His group showed the appearance of magnetic moments in clusters of transition atoms and the existence of scaling laws for diluted spin glasses. The magnetic susceptibility of isolated impurities submitted to Kondo effect was separated from that of magnetic clusters. The disappearance of Kondo effect by antiparallel coupling of nuclear and electronic spins ½, the local spin fluctuations and electronic moments induced by nuclear moments in Praseodymium Van Vleck compounds were also discovered. The coexistence between superconductivity and ferromagnetism was studied or discovered in few compounds.

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