A Hidden Parameter for Supercooling Behavior and Glass Formation: Hypercooling Limit

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Solidification behavior from supercooled liquids is classified with two types, i.e., hypercooling and hypocooling, depending on the degree of supercooling. In particular, hypercooling behavior which shows deep supercooling beyond a certain limit, is practically important to manipulate glass formation as well as crystal nucleation and growth. However, it is still very ambiguous how the hypercooling occurs and impacts on glass formation. In the present work, we reveal the cause of hypercooling and its role in glass formation. Remarkably, we find that the hypercooling behavior of liquids is determined by the combination of undercoolability and hypercoolability, unlike the common belief that deep supercooling is the prerequisite to observe hypercooling. This provides an answer for a long-standing question of why certain materials show hypercooling behavior, although their liquids only have small degree of supercooling. In addition, we find that the hypercooling behavior is affected by density difference of crystal and liquid at melting temperature. Moreover, we find a clear connection between hypercooling limit and glass forming ability, which explicitly reveals the hidden role of hypercooling limit in glass formation in both thermodynamic and kinetic viewpoints.