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Fragility of Metallic Glasses and the T_A/T_G Ratio

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A liquid's viscosity, η, increases exponentially as its temperature decreases towards the glass transition temperature, T_g, defined as the temperature at which the shear viscosity reaches a value of 10^{12} Pascal-seconds (Pa·s). However, for different liquids, there are large disparities in the exact temperature dependence of the viscosity. When $\log_{10}(\eta)$ is plotted versus the reduced temperature T_g/T, some liquids have a linear (Arrhenius) viscosity temperature dependence, while others are highly nonlinear (super-Arrhenius). This departure from Arrhenius behavior is known as the liquid's kinetic fragility (denoted by the letter m), and is typically characterized by the slope of $\log_{10}(\eta)$ at T_g, $m=\frac{d\log(\eta)}{d(Tg/T)}|_{T=Tg}$. Kinetic fragility has been correlated with various fundamental properties of the liquid, including its rate of structural ordering, the character of its interaction potential, and how well it forms a glass. Recently, kinetic fragility has also been related to the so-called Arrhenius crossover temperature, T_A, below which the liquid begins to exhibit cooperative properties. The Kelton Research Group has previously argued that the ratio T_A/T_g is correlated with m; however, the data have significant scatter in the relationship. This could be due to the data spanning disparate families of liquids, ranging from silicate, molecular, network, polymer, and metallic, and could also be due to differences in quantitative methods used to measure m, T_g, and T_A. Thus, it would be instructive to limit the study of the relationship between m and T_A/T_g to a small family of similar liquids and use identical methods to determine m, T_A, and T_g for all liquids in the study. This research focuses on this study.