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Title: Simulating the Evolution of Galaxies and Clusters of Galaxies

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The formation of cosmic structures is driven on the largest scales by the force of gravity, which amplifies weak density fluctuations such as those thought to arise from microscopic conditions in the very early universe. Our understanding of this process has advanced greatly over the past 40 years due to the application of computer simulation techniques. Among the many important things we have learned from the interplay of these simulations with observations of the galaxy distribution is that the matter content of the universe is dominated by a dynamically cold, weakly interacting, non-baryonic component -- ``cold dark matter." However, gravity is not the end of the story: we see galaxies because of the baryons they contain, and these baryons are subject to pressure, radiation, and magnetic effects in addition to gravity. Understanding how these complex interactions led to the stellar populations, interstellar and intergalactic diffuse gas, and central supermassive black holes that we observe today lies at the frontier of computational cosmology. I will review the lessons simulations have taught us about the formation of the largest cosmic structures, highlight some of the numerical methods that have made these advances possible, and discuss open questions and how they might be addressed using forthcoming generations of computers.