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TOPICAL REVIEW

Cosmology and gravity in the new era of multi-messenger astronomy

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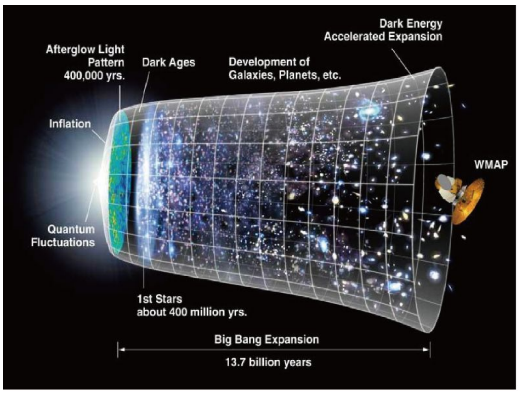
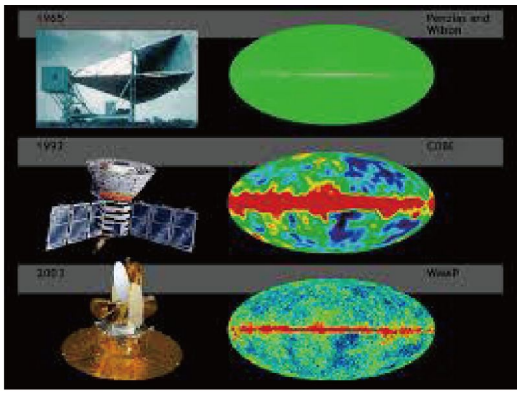
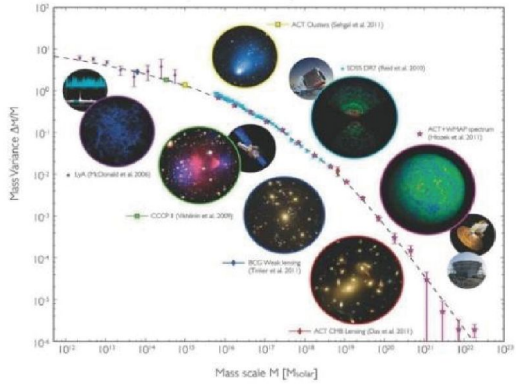
Highlights

Once upon a time there was a concrete, holistic, self-consistent and perfect cosmological paradigm in agreement with all observations, a model so successful that became the most long-lived scientific system in history: the Aristotelian-Ptolemaic cosmological and physical paradigm. After 1500 years of successes, the technological and scientific advance led to detailed observations, experiments and theoretical investigation that in turn led to tensions and thus to its replacement by Newtonian gravity and celestial mechanics, namely a concrete, holistic, self-consistent and perfect paradigm in agreement with all observations. After 250 years of successes, the technological and scientific advance led to detailed observations, experiments and theoretical investigation that in turn led to tensions and thus to its replacement by general relativity and LambdaCDM cosmology, namely a concrete, holistic, self-consistent and perfect paradigm in agreement with all observations. So, what is the future of general relativity and LambdaCDM cosmology? Will the technological and scientific advance lead to detailed observations, experiments and theoretical investigation that in turn will lead to tensions that will lead to their replacement? Have we entered this period already? Will multi-messenger astronomy lead to new physics?







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Abstract We review the standard model of cosmology and gravity, namely Lambda-CDM paradigm and general relativity. We mention their successes and we describe possible tensions that appear between theoretical predictions and observations, that may ask for modifications of the standard lore. Finally, we describe how gravitational wave observations and multi-messenger astronomy provides a new tool to investigate the universe.

Keywords cosmology, gravity, general relativity, modified gravity, dark energy, dark matter, inflation, black holes, gravitational waves, multi-messenger astronomy

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