PRESS RELEASE
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Back to the future of galaxy clusters

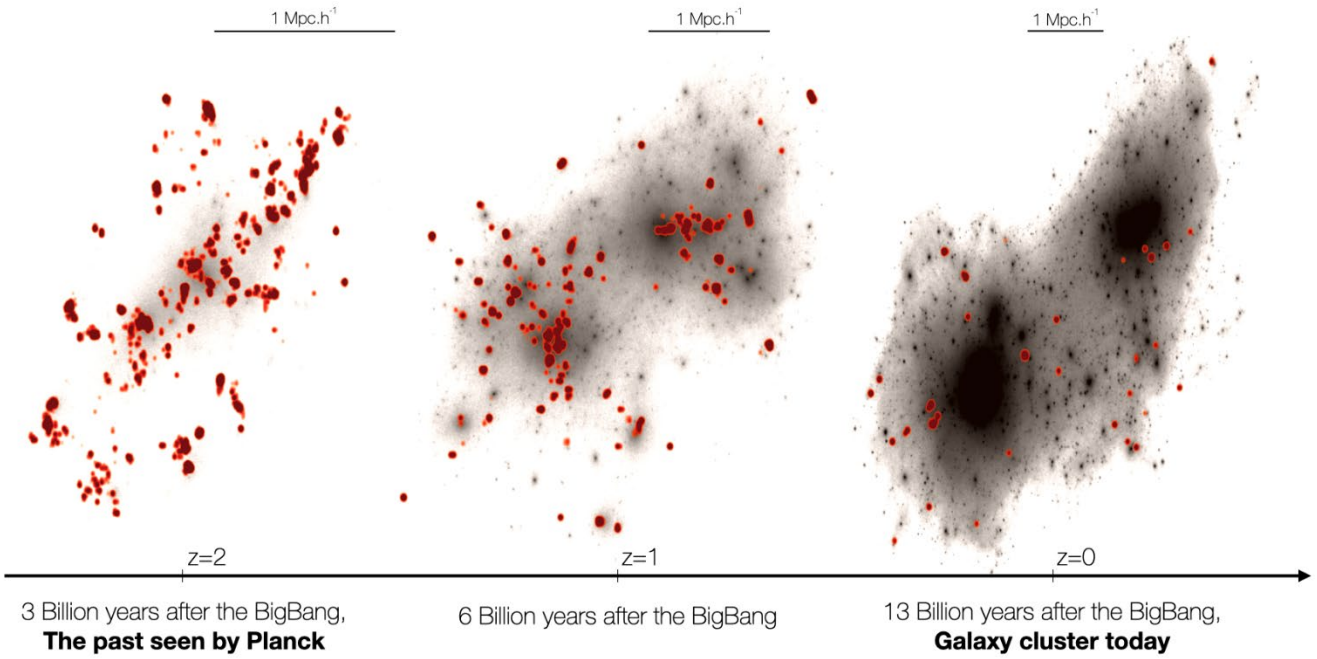
Based on an original analysis of state-of-the art numerical simulations, an international team of astrophysicists led by researchers from the Institut d'Astrophysique Spatiale, IAS (CNRS / Univ. Paris-Saclay), and from institutes in Italy and South Korea, has successfully predicted the future of distant galaxy clusters discovered by the Planck satellite. Their analysis shows that around 70% of them will likely evolve into massive galaxy clusters.

Protoclusters are clusters of galaxies at a young stage in their evolution, which we observe in the distant Universe. These observations are evidence of a very specific period in the history of the Universe, when star formation was at its zenith. Up to now, it has been difficult to reconcile theoretical models with the very high star-formation rate in sources likely to host distant protoclusters measured by the Planck satellite, raising questions about our understanding of the evolution of galaxies within the large-scale structures of the Universe.

Using publicly available state-of-the-art hydrodynamic cosmological simulations, the international team led by researchers from the Institut d'Astrophysique Spatiale (IAS) has shown that the candidate protoclusters detected by Planck can be explained by the presence of a group of very active star-forming galaxies, and by the signal from other galaxies present between the source and the observer. For the first time, and about ten years after their detection, very good understanding has been established between the precise structure formation modelling from the simulations and the sources detected by Planck, in particular the number of galaxies they contain, their masses, and their capacity to form stars.

Beyond this first interpretation of the observations, the researchers have provided a prediction of the fate of the candidate protoclusters detected by the Planck mission. They show that the vast majority, up to 70%, of the sources detected by Planck will evolve into true massive galaxy clusters in the future. The other protocluster candidates will not evolve to reach the galaxy cluster stage, but will most likely remain a population of individual, massive and high star-forming galaxies.

"*If six distant star-forming galaxies or more are gravitationally bound, then there is over 90% chance they will become a massive galaxy cluster in the future,*" explains Dr Céline Gouin, the first author of this study published in the *Astronomy & Astrophysics* journal and member of the ERC ByoPiC project. The number of interlinked star-forming galaxies would thus be a determining factor for distinguishing which distant structure is a forming cluster of galaxies. This discovery and the new quantitative criterion open the way to future protocluster detection strategies, and both are promising for new space missions to explore distant galaxies and their evolution (JWST and Euclid).



The star formation areas (in red) are disappearing with time, whereas the cluster of dark matter is growing (in black). Ages ago, at time epochs probed by the mission Planck, the proto-clusters of galaxies were forming a lot of stars, whereas today these massive structures have become passive, and didn't form a lot of new stars. © Gouin et al., 2022, IAS, with IllustrisTNG simulations

Références :

Questioning Planck-selected star-forming high-redshift galaxy protoclusters and their fate, by C. Gouin[1,2], N. Aghanim[2], H. Dole[2], M. Polletta[3] and C. Park[1], 2022, *A&A*, 664, A155
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