

Prediction of the Milky Way–Andromeda Galaxy Merger: A Review of Astrophysical Evidence

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Abstract

The Milky Way and Andromeda galaxies are expected to collide and merge in approximately 4 to 5 billion years, forming a single elliptical galaxy. This prediction is based on precise measurements of proper motion and radial velocity from the Hubble Space Telescope and the ESA Gaia mission. This document summarizes the scientific consensus on this galactic merger, its timeline, physical implications, and astrophysical significance.

1 Introduction

Galactic collisions are fundamental events in cosmic evolution. The Milky Way (MW) and the Andromeda Galaxy (M31) are the two largest members of the Local Group. Observational data indicate that M31 is approaching the Milky Way, setting the stage for a major merger event.

2 Observational Evidence

2.1 Hubble Space Telescope Data

van der Marel et al. (2012) used Hubble observations to calculate the transverse velocity of Andromeda and confirmed its approach at a speed of ~ 110 km/s.

2.2 Gaia Mission Data

Gaia's precise astrometry refined the measurements of local stellar motion, confirming the Local Group's dynamics and improving the collision timeline (Gaia Collaboration, 2021).

3 Merger Timeline

Simulations by Cox & Loeb (2008) and others predict:

- First contact: ~ 4 billion years from now.
- Full merger: ~ 6 billion years from now.
- Final galaxy: massive elliptical (nicknamed “Milkomeda”).

4 Expected Outcomes

- **Galactic Morphology:** Transition from spiral to elliptical.
- **Star Systems:** Extremely low probability of direct star-star collisions.
- **Solar System Fate:** Likely relocation to outer halo; unlikely to be ejected or destroyed.
- **Dark Matter Halos:** Their interaction drives much of the merger dynamics.

5 Scientific Significance

This merger exemplifies hierarchical structure formation in the Λ CDM model of cosmology. It provides insights into:

- Galaxy evolution and growth via mergers.
- Stellar kinematics in large-scale gravitational systems.
- The ultimate fate of the Local Group.

6 Conclusion

The Milky Way–Andromeda merger is a robust prediction grounded in empirical observation and theoretical modeling. It is a natural part of cosmic evolution and offers a preview of our galaxy’s long-term future.

References

References

- Cox, T. J., & Loeb, A. (2008). The collision between the Milky Way and Andromeda. *Monthly Notices of the Royal Astronomical Society*, **386**(1), 461–474.
- van der Marel, R. P., Fardal, M., Besla, G., Beaton, R. L., Sohn, S. T., Anderson, J., ... & Brown, T. M. (2012). The M31 velocity vector. I. Hubble Space Telescope proper-motion measurements. *The Astrophysical Journal*, **753**(1), 8.
- Gaia Collaboration. (2021). Gaia Early Data Release 3: Summary of the contents and survey properties. *Astronomy & Astrophysics*, **649**, A1.