Investigating the past and future of the universe using statistical methods to measure distance

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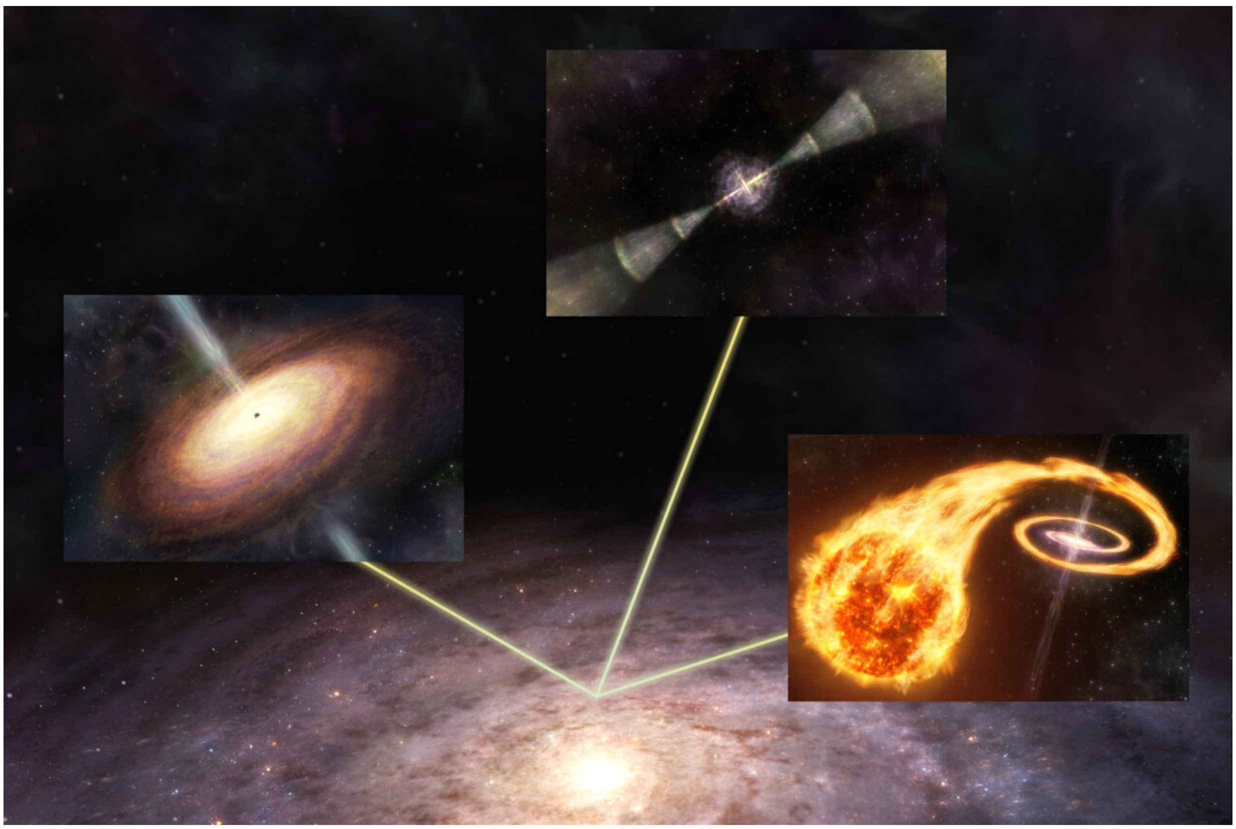

A conceptual diagram of this research. Signals from supernovae (bottom right inset), quasars (middle left inset), and gamma-ray bursts (top center inset) reach Earth in the Milky Way Galaxy (background), where we can use them to measure cosmological parameters. Credit: NAOJ

New research has improved the accuracy of the parameters governing the expansion of the universe. More accurate parameters will help astronomers determine how the universe grew to its current state and how it will evolve in the future.

It is well established that the universe is expanding. But with no landmarks in space, it is difficult to accurately measure how fast it is expanding. So, astronomers search for reliable landmarks. The same way a candle looks fainter as it gets farther away, even though the candle itself hasn't changed, distant objects in the universe look fainter.

If we know the intrinsic (initial) brightness of an object, we can calculate its distance based on its observed brightness. Objects of known brightness in the universe that allow us to calculate the distance are called "standard candles."

An international team led by Maria Giovanna Dainotti, Assistant Professor at the National Astronomical Observatory of Japan (NAOJ), and Giada Bargiacchi, Ph.D. student at the Scuola Superiore Meridionale in Naples, with the aid of the supercomputing facilities at NAOJ run by Kazunari Iwasaki, Assistant Professor at NAOJ and member of the Center for Computational Astrophysics, ushered in a new research field by leveraging the use of a variety of new statistical methods.

They have analyzed data for various standard candles such as supernovae, quasars (powerful black holes consuming matter in the distant universe), and gamma ray bursts (sudden flashes of powerful radiation). Different standard candles are useful in different distant ranges, so combining multiple standard candles allowed the team to map larger areas of the universe. Their work has been published in two articles in *The Astrophysical Journal*.

The new results reduce the uncertainty of key parameters by up to 35%.

More accurate parameters will help determine whether the universe will continue expanding forever or will eventually fall back in on itself.

More information: Maria Giovanna Dainotti et al, Reducing the Uncertainty on the Hubble Constant up to 35% with an Improved Statistical Analysis: Different Best-fit Likelihoods for Type Ia Supernovae, Baryon Acoustic Oscillations, Quasars, and Gamma-Ray Bursts, *The Astrophysical Journal* (2023). DOI: 10.3847/1538-4357/acd63f

M. G. Dainotti et al, Quasars: Standard Candles up to z = 7.5 with the Precision of Supernovae Ia, *The Astrophysical Journal* (2023). DOI: 10.3847/1538-4357/accea0

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