The Little Bang

Was Our Galactic Backyard the Scene of Past Violence?

By RON COWEN

Cannibalism, collisions, crashes?

The environs of the Milky Way and its galactic neighbors don't seem a likely place for acts of cosmic violence. These galaxies move serenely across the sky with nary a hint of any past trauma.

But about 8 billion years ago, one or more pairs of galaxies may have smashed into Andromeda, the spiral galaxy nearest the Milky Way. Andromeda probably devoured one or two of the intruders; the others managed to flee. The Milky Way, a mere bystander in the mêlée, gravitationally grabbed several small galaxies that had originally belonged to Andromeda.

Such a hubbub in our galactic backyard, though fascinating in its own right, may have a broader significance. Combined with the recent discovery of additional dwarf galaxies a few million light-years from the Milky Way, it might help astronomers obtain a better estimate of the total amount of mass—both visible and dark matter—in nearby galaxies. This, in turn, would provide a new clue to the age of the universe

Astronomers caution that they have yet to prove this violent episode actually took place. But several lines of evidence suggest that some kind of cataclysmic event did occur in our neck of the cosmic woods several billion years ago. Researchers call it the Little Bang.

Unlike the Big Bang, which most astronomers believe sparked the birth of the cosmos and left behind a universal whisper of radiation, the Little Bang made no definitive mark on our galactic neighborhood. However, a team of astronomers that includes Gene Byrd of the University of Alabama in Tuscaloosa, Marshall McCall and Kimmo Innanen of York University in North York, Ontario, and Mauri Valtonen and Jia-Qing Zheng of Tuorla Observatory in Pikkiö, Finland, cite several clues pointing to past violence.

Consider, notes Byrd, the large galaxies Maffei 1 and IC 342. These bodies reside just beyond the Local Group, a collection of about 30 galaxies that includes the two superpowers—the Milky Way and Andromeda—and their satellite galaxies.

In our expanding universe, all bodies tend to move apart at a rate that increases with their separation. But superimposed on this general trend are small-scale motions caused by the gravitational tug of one galaxy on another. Given their proximity to the Milky Way, Maffei 1 and IC 342 seem to be moving away more rapidly than cosmic expansion alone would dictate.

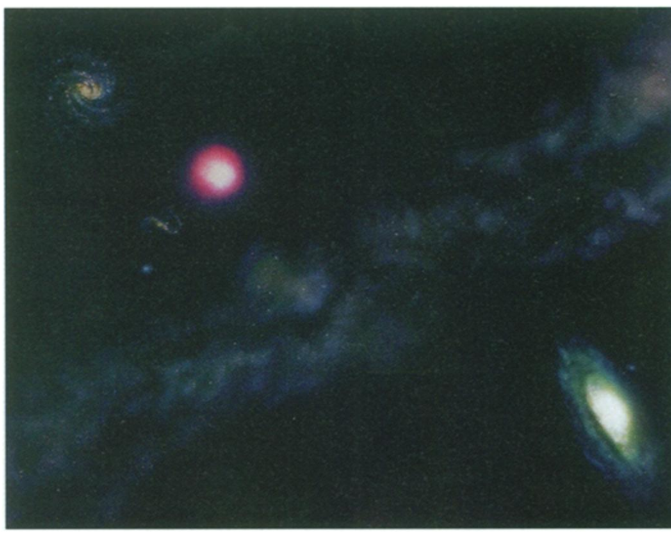


Photo courtesy York Univ/Illustration: Dan Fell

Illustration of the galactic neighborhood as seen from Earth; distances are not drawn to scale. From upper left to lower right are the spiral galaxy IC 342, the elliptical galaxy Maffei 1 (shown in pink-orange), a long diagonal arc of the Milky Way, and Andromeda. Just below and slightly to the left of Maffei 1 lie the galaxy's newly discovered satellites, MB1 and MB2.

Simulations by Valtonen and his colleagues indicate that when the first pair of galaxies crashed into Andromeda some 8 billion years ago, the galaxy captured one and ejected the other. The same thing happened when the second pair collided with Andromeda. The two ejected galaxies, former members of the Local Group, were IC 342 and Maffei 1.

In the same way that firing a bullet gives a gun an opposing kick, the ejected matter would have prompted massive Andromeda to recoil slightly in the opposite direction. This could explain why Andromeda now moves toward our galaxy at 120 kilometers per second, while IC 342 and Maffei 1 recede in nearly the opposite direction at speeds of 170 and 145 km per second, respectively.

Byrd cautions that because Maffei 1 and IC 342 reside in dust-shrouded locations behind the Milky Way, astronomers still don't have an accurate measure of their distances. If they lie farther from the Milky Way than he and his colleagues have assumed, all bets are off. There would be no need for a Little Bang to account for their speed.

Other clues support the collision scenario. Andromeda's own anatomy provides several. Observations with the Hubble Space Telescope in 1993 revealed that the center of Andromeda sports twin peaks—two regions of concentrated light emission instead of one. This double nucleus suggests that Andromeda merged with another galaxy sometime in the past.

In addition, astronomers have long known that Andromeda's center has a lower than expected density of globular clusters—closely packed groupings of elderly stars. What's more, the distribution of globular clusters in Andromeda has an unusual feature. In many galaxies, clusters nearer the center have higher concentrations of elements heavier than helium; those in Andromeda don't.

These findings support the view that Andromeda suffered a major collision and merger, whereas our galaxy did not, Valtonen and his collaborators assert. They argue that collisions and mergers could have ripped apart globular clusters at the center of Andromeda, thus accounting for the reduced number of clusters there. The events may also have scattered the clusters, scrambling the usual correlation between heavy-element concentration and proximity to the galaxy's center.

Three members of the Local Group—all of them satellite galaxies of the Milky Way—display some unusual properties that can be explained by a past encounter with Andromeda, Byrd notes. The Large and Small Magellanic Clouds, our galaxy's biggest satellites, orbit the Milky Way faster than gravity alone requires. In other words, they have more angular momentum than astronomers would expect. Another satellite galaxy, Leo I, speeds away from the Milky Way at 177 km per second, far faster than any other satellite moving toward or away from the galaxy.

The team proposes that these lightweight galaxies represent debris that Andromeda hurled toward the Milky Way in the aftermath of the Little Bang. Once they escaped the clutches of Andromeda, the three ejected bodies may have moved into a region of space dominated by the Milky Way's gravity. Trading one master for another, the galaxies became enslaved to the Milky Way about 6 billion years ago, the researchers calculate.

"The new view of the Local Group can provide a reason for the departure [from Andromeda] and explain the clouds' angular momentum problem," the researchers reported in the June 1994 ASTRONOMICAL JOURNAL. The high velocity of Leo 1 could have a similar explanation, they note.

The recent discovery of two galaxies that appear to be close companions of Maffei 1 may shed further light on the chain of events that led to its showdown with Andromeda. Analysis of the motion of these two galaxies may help astronomers measure the mass of Maffei 1—both its visible stars and glowing gas and the far larger component of invisible, or dark, matter.

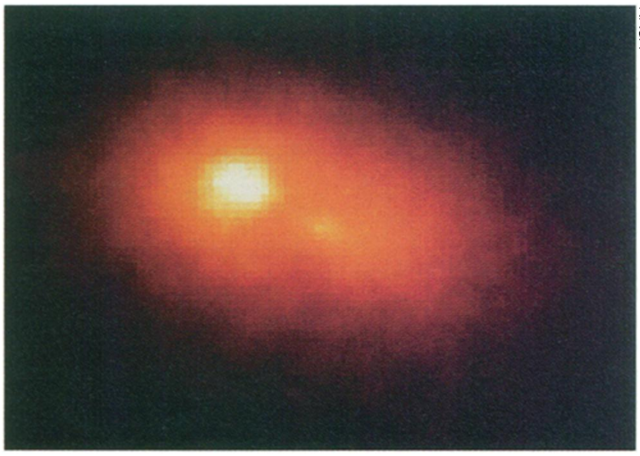
"[By] knowing the amount of matter out there around Maffei 1, it will be possible to quantify better its past gravitational interactions with the Andromeda galaxy and the Milky Way," says codiscoverer McCall.

One of the objects, thought to be a spiral galaxy, may also help firm up estimates of the distance to Maffei 1. This, in turn, would provide a better estimate of the age of the universe inferred from the current positions and velocities of galaxies near the Milky Way. McCall and Ronald J. Buta, also at Alabama, report their discovery in this month's ASTRONOMICAL JOURNAL.

Three years ago, the astronomers were studying the brightness of Maffei 1, using a 60-centimeter infrared telescope atop Arizona's Kitt Peak to see through the Milky Way's dust. Only after lengthy analysis of these images did the team make its accidental discovery of the two objects. "It was like shucking an oyster and finding two pearls inside," says McCall.

The two faint bodies, labeled MB1 and MB2, lie about 10 million light-years from Earth. Last year, another team of astronomers discovered an additional galaxy in the same part of the sky, although this one may lie farther from Maffei 1 than MB1 and MB2 (SN: 11/5/95, p.292).

MB1 may be a spiral and appears to measure about 17,000 light-years across—making it about 15 percent of the Milky Way's size.



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***H**ubble Space Telecope's view of the double nucleus at the heart of Andromeda.*

The close association of MB1 and MB2 with Maffei 1 leads McCall and Buta to believe that Maffei 1 is tearing material from its two satellites. Radio observations of MB1, taken with the 100-meter Effelsberg telescope near Bonn, Germany, support that view. (MB2 wasn't detected at radio wavelengths.) Walter K. Huchtmeier of the Max Planck Institute for Radio Astronomy in Bonn found that MB1 contained relatively little hydrogen gas. The researchers suggest that Maffei 1 has gravitationally stolen the missing gas.

Byrd calls the findings "an embarrassment of riches."

"On the one hand," he says, the two galaxies "will provide a better distance estimate to Maffei 1. But [with more galaxies to consider] it will be harder to reconstruct the details of the interaction with Andromeda."

Deducing the age of the universe from the interactions of local galaxies is a two-step process, says Byrd. Valtonen and his colleagues began with the standard assumption that all bodies that have interacted since the birth of the universe once lay near each other. That time is considered the beginning of the universe.

Astronomers simulating the past motion of galaxies near the Milky Way can't turn the clock all the way back to the Big Bang in one fell swoop, however. The Little Bang gets in the way. "Maffei 1 and IC 342. . . are near enough to [Andromeda] and massive enough to have had a significant influence on the dynamics of the Local Group in the past 10 billion years, upsetting efforts to determine. . . the age of the universe through Local Group timing," write Buta and McCall.

After accounting for the kick Andromeda received in the aftermath of the Little Bang, Valtonen and his colleagues continued their backwards extrapolation, calculating that the Milky Way and Andromeda were intimate neighbors 15.5 billion years ago. The Big Bang occurred at this time, Valtonen reported last October at the University of Maryland's annual astronomy meeting in College Park.

The notion of the Little Bang remains controversial. Using a novel technique based on statistical fluctuations in the brightness of a galaxy, John L. Tonry of the Massachusetts Institute of Technology and his colleagues estimate that Maffei 1 lies about 13 billion light-years from Earth. That's too far, he says, for the large galaxy to have collided with Andromeda 8 billion years ago. The Little Bang "is a fun idea, but I think it's wrong," Tonry adds.

McCall notes that astronomers still don't know the distance to Maffei 1 with certainty. Even if the galaxy resided slightly farther away than Tonry calculates—up to 16 billion light-years—it might still have smashed into Andromeda, McCall maintains.

Byrd adds that even if Maffei 1 lies too far away, its neighbor, IC 342, may qualify as a Little Bang participant. "From the point of view of the dynamics, it's easier to figure out what happened in the past if there's just one galaxy [to account for] instead of two." Moreover, he says, "the double nucleus of Andromeda indicates that *something* happened, even if these two galaxies [Maffei 1 and IC 342] are not ejected debris from a collision."

For now, McCall and his coworkers want to work on getting accurate distances to IC 342 and Maffei 1. To estimate how far away Maffei 1 lies, they focus on its newly discovered close companion, the spiral galaxy MB1. The rotation of a spiral galaxy indicates its true luminosity: The faster it rotates, the brighter it is. By comparing the true brightness of MB1 to its apparent brightness in the sky, the researchers can, in theory, determine its distance.

In practice, they will have to estimate the amount of dust obscuring that galaxy from ours, a factor that reduces further the amount of light reaching Earth. That's a tricky business, but the fate of the Little Bang hangs in the balance. □