WE ARE GALAXY STUFF

Carl Sagan famously once said that we are made of star stuff. He meant the carbon, nitrogen and oxygen atoms in our bodies, as well as atoms of all other heavy elements, were once created inside stars in our Milky Way galaxy.

Yet Sagan's expression of this idea, which quickly became a cornerstone of popular culture, might not take the concept far enough. According to astrophysicists at Northwestern University, our origins are much less local than previously thought. In fact, according to their analysis – which they say is the first of its kind – we're not just star stuff. We're galaxy stuff. The analysis – based on supercomputer simulations – reveals that each one of us may be made in part from matter that passes from one galaxy to another in a continuous exchange.

This image shows a pair of nearby galaxies M81 (bottom right) and M82 (upper left),where intergalactic transfer might be happening.

The Northwestern researchers found that up to half of the matter in our Milky Way galaxy may come from distant galaxies. As a result, each one of us may be made in part from extragalactic matter. That is, atoms of carbon, nitrogen, oxygen and so on in our bodies may be created not just by the stars in our own galaxy, but by stars in far-flung galaxies. They arrived at this conclusion using supercomputer simulations. The study required the equivalent of several million hours of continuous computing. The simulations show that supernova explosions eject great quantities of gas from galaxies, which causes the atoms made inside stars to be transported from one galaxy to another via powerful galactic winds. According to their statement, intergalactic transfer is a newly identified phenomenon, which, they say, requires supercomputer simulations in order to be understood.

According to these astrophysicists, this understanding is critical for knowing how galaxies evolve … and hence for knowing our own place in the universe.

Daniel Anglés-Alcázar is a postdoctoral fellow in Northwestern's Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA). He led the study, and he said:

> *It is likely that much of the Milky Way's matter was in other galaxies before it was kicked out by a powerful wind, travelled across intergalactic space and eventually found its new home in the Milky Way. Given how much of the matter out of which we formed may have come from other galaxies, we could consider ourselves space travelers or extragalactic immigrants. Even though space is vast and galaxies are located at almost inconceivable distances from each other, some winds propagate at thousands kilometres per second and the process of intergalactic transfer occurs over billions of years.*

The study of galaxy formation and their interaction over time, collisions, mergers and general growth is an ongoing process, and this new research built on earlier studies. Northwestern's **Claude-André Faucher-Giguère** and his research group, along with a unique collaboration called Feedback In Realistic Environments (FIRE), had developed numerical simulations that produced realistic 3-D models of galaxies. These simulations followed a galaxy's formation from just after the Big Bang to the present day. The Northwestern team plans to collaborate with observational astronomers who are working with the Hubble Space Telescope and ground-based observatories to test the simulation predictions.

The Milky Way is part of what is called the Local Group, which comprises more than 54 galaxies, most of them dwarf galaxies. Its gravitational centre is located somewhere between the Milky Way and the Andromeda Galaxy. The Local Group has a diameter of 10 Mly and has a binary distribution. The group itself is a part of the larger Virgo Supercluster, which may be a part of the Laniakea Supercluster. The three largest members of the group (in decreasing order) are the Andromeda Galaxy, the Milky Way and the Triangulum Galaxy. The larger two have their own system of satellite galaxies.

Simulations of gravitational interactions have come a long way since Newton's day, when a three-body problem seemed beyond resolution. AK, with Wikipedia Notes