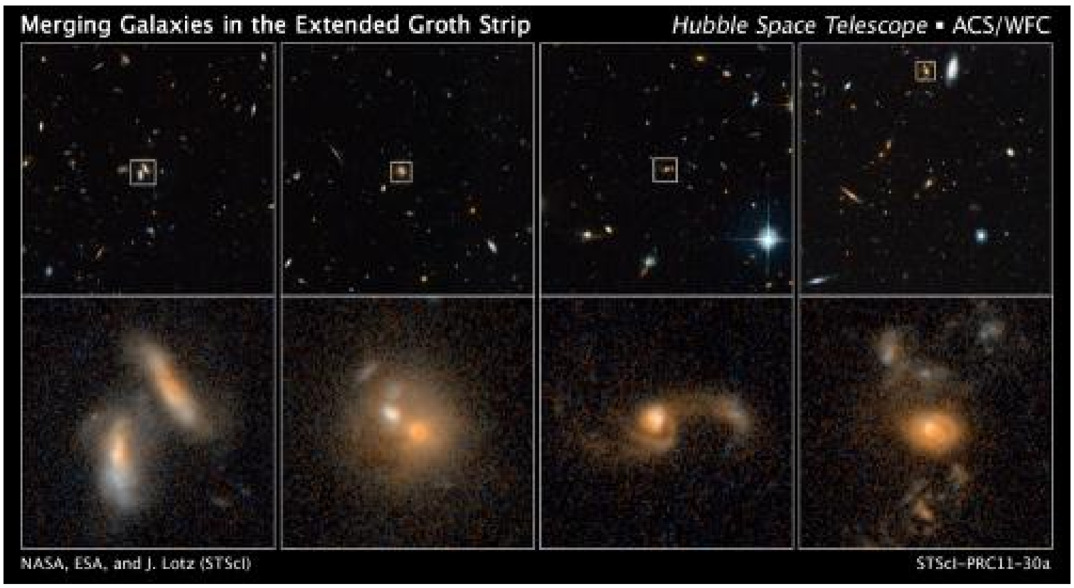
Astronomers pin down galaxy collision rate

October 27 2011



These images from NASA's Hubble Space Telescope show four examples of interacting galaxies far away from Earth. The galaxies, beginning at far left, are shown at various stages of the merger process. The top row displays merging galaxies found in different regions of a large survey known as the All-Wavelength Extended Groth Strip International Survey (AEGIS). The images were taken in 2004 and 2005 by Hubble's Advanced Camera for Surveys. Credit: NASA, ESA, J. Lotz (STScI), M. Davis (University of California, Berkeley), and A. Koekemoer (STScI)

(PhysOrg.com) -- A new analysis of images from the Hubble Space Telescope combined with supercomputer simulations of galaxy collisions has cleared up years of confusion about the rate at which smaller galaxies merge to form bigger ones. This paper, led by Jennifer Lotz of

Space Telescope Science Institute, is about to be published in the *Astrophysical Journal*.

Galaxies grow mostly by acquiring small amounts of matter from their surroundings. But occasionally galaxies merge with other galaxies large or small. Collisions between big galaxies can change rotating disk galaxies like the Milky Way into featureless elliptical galaxies, in which the stars are moving every which way.

In order to understand how galaxies have grown, it is essential to measure the rate at which galaxies merge. In the past, astronomers have used two principal techniques: counting the number of close pairs of galaxies about to collide and by counting the number of galaxies that appear to be disturbed in various ways. The two techniques are analogous to trying to estimate the number of automobile accidents by counting the number of cars on a collision course versus counting the number of wrecked cars seen by the side of the road.

However, these studies have often led to discrepant results. "These different techniques probe mergers at different 'snapshots' in time along the merger process," Lotz says. "Studies that looked for close pairs of galaxies that appeared ready to collide gave much lower numbers of mergers (5%) than those that searched for galaxies with disturbed shapes, evidence that they're in smashups (25%)."

In the new work, all the previous observations were reanalyzed using a key new ingredient: highly accurate computer simulations of galaxy collisions. These simulations, which include the effects of stellar evolution and dust, show the lengths of time over which close galaxy pairs and various types of galaxy disturbances are likely to be visible. Lotz's team accounted for a broad range of merger possibilities, from a pair of galaxies with equal masses joining together to an interaction between a giant galaxy and a puny one. The team also analyzed the effects of different orbits for the galaxies, possible collision impacts, and how the galaxies were oriented to each other.

The simulations were done by T. J. Cox (now at Carnegie Observatories in Pasadena), Patrik Jonsson (now at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts), and Joel Primack (at the University of California, Santa Cruz -- UCSC), using small supercomputers at UCSC and the large Columbia supercomputer at NASA Ames Research Center. These simulations were "observed" as if through Hubble Space Telescope by Jennifer Lotz in a series of papers with Cox, Jonsson, and Primack that were published over the past three years. A key part of the analysis was a new way of measuring galaxy disturbances that was developed by Lotz, Primack, and Piero Madau in 2004. All this work was begun when Lotz was a postdoc with Primack, and Cox and Jonsson were his graduate students.

"Viewing the simulations was akin to watching a slow-motion car crash," Lotz says. "Having an accurate value for the merger rate is critical because galactic collisions may be a key process that drives galaxy assembly, rapid star formation at early times, and the accretion of gas onto central supermassive black holes at the centers of galaxies."

"The new paper led by Jennifer Lotz for the first time makes sense of all the previous observations, and shows that they are consistent with theoretical expectations," says Primack. "This is a great example of how new astronomical knowledge is now emerging from a combination of observations, theory, and supercomputer simulations." Primack now heads the University of California High-Performance AstroComputing Center (UC-HiPACC), headquartered at the University of California, Santa Cruz.

The simulated galaxy merger images have been gathered into an archive called Dusty Interacting Galaxy Gadget-Sunrise Simulations (DIGGSS, at http://archive.stsci.edu/prepds/diggss/) and placed in the Multimission Archive at STSci (MAST), the online archive otherwise used only for images from space telescopes.

More information: The paper by Lotz et al., entitled "The Major and Minor Galaxy Merger Rates at z
adsabs.harvard.edu/abs/2011arXiv1108.2508L

Provided by University of California - Santa Cruz