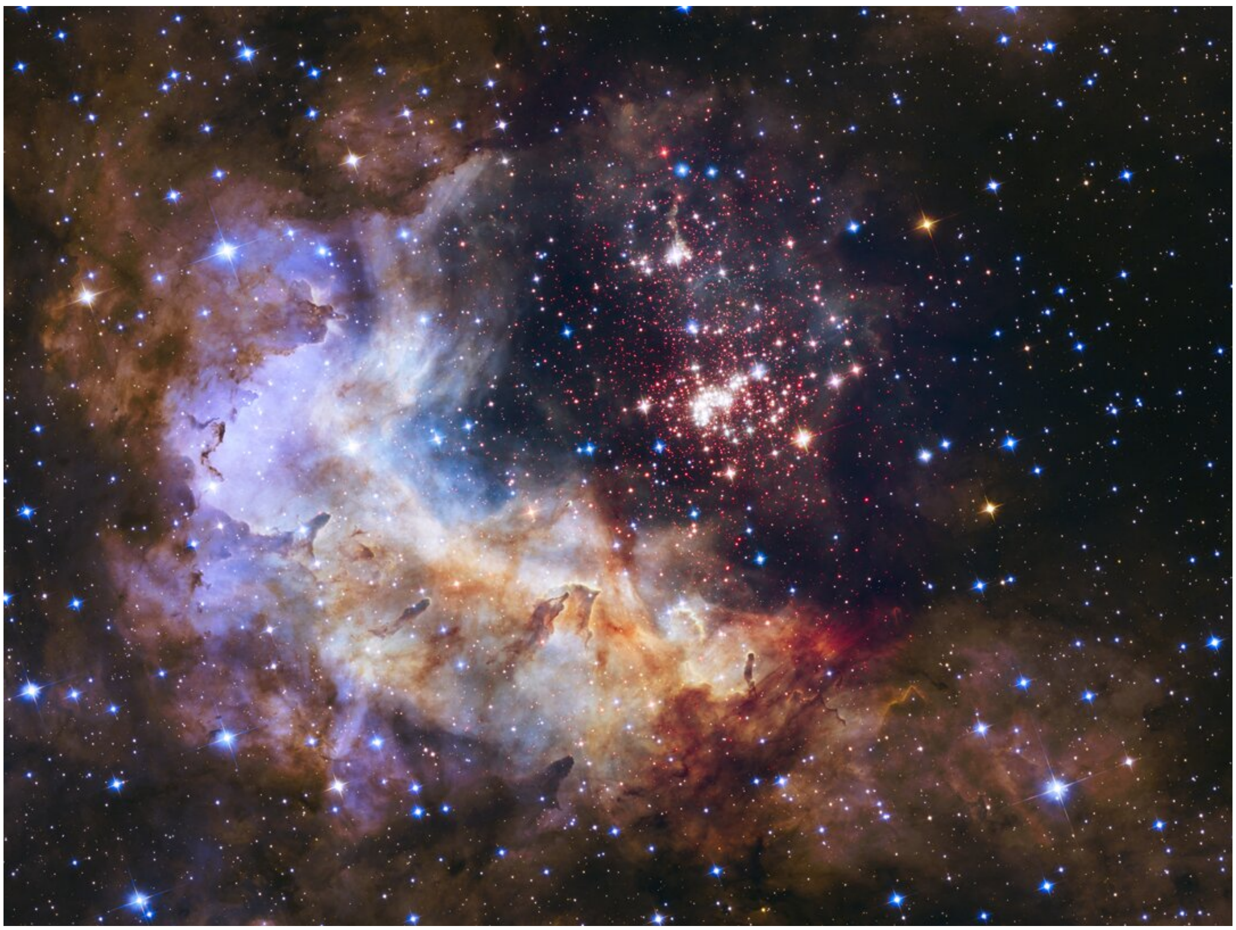
In planet formation, it's location, location, location

May 28 2020, by Claire Andreoli



The brilliant tapestry of young stars flaring to life resembles a glittering fireworks display in this Hubble Space Telescope image. The sparkling centerpiece of this fireworks show is a giant cluster of thousands of stars called Westerlund 2. The cluster resides in a raucous stellar breeding ground known as Gum 29, located 20,000 light-years away from Earth in the constellation Carina. Hubble's Wide Field Camera 3 pierced through the dusty veil shrouding the stellar nursery in near-infrared light, giving astronomers a clear view of the nebula and the dense concentration of stars in the central cluster. The cluster measures between six light-years and 13 light-years across. Credit: NASA, ESA, the Hubble Heritage Team (STScI/AURA), A. Nota (ESA/STScI) and the Westerlund 2 Science Team

Astronomers using NASA's Hubble Space Telescope are finding that planets have a tough time forming in the rough-and-tumble central region of the massive, crowded star cluster Westerlund 2. Located 20,000 light-years away, Westerlund 2 is a unique laboratory to study stellar evolutionary processes because it's relatively nearby, quite young, and contains a large stellar population.

A three-year Hubble study of stars in Westerlund 2 revealed that the precursors to planet-forming disks encircling stars near the cluster's center are mysteriously devoid of large, dense clouds of dust that in a few million years could become planets.

However, the observations show that stars on the cluster's periphery do have the immense planet-forming dust clouds embedded in their disks. Researchers think our solar system followed this recipe when it formed 4.6 billion years ago.

So why do some stars in Westerlund 2 have a difficult time forming planets while others do not? It seems that planet formation depends on location, location, location. The most massive and brightest stars in the cluster congregate in the core, which is verified by observations of other star-forming regions. The cluster's center contains at least 30 extremely massive stars, some weighing up to 80 times the mass of the Sun. Their blistering ultraviolet radiation and hurricane-like stellar winds of charged particles blowtorch disks around neighboring lower-mass stars, dispersing the giant dust clouds.

"Basically, if you have monster stars, their energy is going to alter the properties of the disks around nearby, less massive stars," explained Elena Sabbi, of the Space Telescope Science Institute in Baltimore and lead researcher of the Hubble study. "You may still have a disk, but the stars change the composition of the dust in the disks, so it's harder to create stable structures that will eventually lead to planets. We think the dust either evaporates away in 1 million years, or it changes in composition and size so dramatically that planets don't have the building blocks to form."

The Hubble observations represent the first time that astronomers analyzed an extremely dense star cluster to study which environments are favorable to planet formation. Scientists, however, are still debating whether bulky stars are born in the center or whether they migrate there. Westerlund 2 already has massive stars in its core, even though it is a comparatively young, 2-million-year-old system.

Using Hubble's Wide Field Camera 3, the researchers found that of the nearly 5,000 stars in Westerlund 2 with masses between 0.1 to 5 times the Sun's mass, 1,500 of them show fluctuations in their light as the stars accrete material from their disks. Orbiting material clumped within the disk would temporarily block some of the starlight, causing brightness fluctuations.

However, Hubble detected the signature of such orbiting material only around stars outside the cluster's packed central region. The telescope witnessed large drops in brightness for as much as 10 to 20 days around 5% of the stars before they returned to normal brightness. They did not detect these dips in brightness in stars residing within four light-years of the center. These fluctuations could be caused by large clumps of dust passing in front of the star. The clumps would be in a disk tilted nearly edge-on to the view from Earth. "We think they are planetesimals or structures in formation," Sabbi explained. "These could be the seeds that eventually lead to planets in more evolved systems. These are the systems we don't see close to very massive stars. We see them only in systems outside the center."

Thanks to Hubble, astronomers can now see how stars are accreting in environments that are like the early universe, where clusters were dominated by monster stars. So far, the best known nearby stellar environment that contains massive stars is the starbirth region in the Orion Nebula. However, Westerlund 2 is a richer target because of its larger stellar population.

"Hubble's observations of Westerlund 2 give us a much better sense of how stars of different masses change over time, and how powerful winds and radiation from very massive stars affect nearby lower-mass stars and their disks," Sabbi said. "We see, for example, that lower-mass stars, like our Sun, that are near extremely massive stars in the cluster still have disks and still can accrete material as they grow. But the structure of their disks (and thus their planet-forming capability) seems to be very different from that of disks around stars forming in a calmer environment farther away from the cluster core. This information is important for building models of planet formation and stellar evolution."

This cluster will be an excellent laboratory for follow-up observations with NASA's upcoming James Webb Space Telescope, an infrared observatory. Hubble has helped astronomers identify the stars that have possible planetary structures. With Webb, researchers can study which disks around stars are not accreting material and which disks still have material that could build up into planets. This information on 1,500 stars will allow astronomers to map a path on how star systems grow and evolve. Webb also can study the chemistry of the disks in different evolutionary phases and watch how they change, and help astronomers determine what influence environment plays in their evolution.

NASA's Nancy Grace Roman Space Telescope, another planned infrared observatory, will be able to perform Sabbi's study on a much larger area. Westerlund 2 is just a small slice of an immense star-formation region. These vast regions contain clusters of stars with different ages and different densities. Astronomers could use Roman Space Telescope observations to start to build up statistics on how a star's characteristics, like its mass or outflows, affect its own evolution or the nature of stars that form nearby. The observations could also provide more information on how planets form in tough environments.

Sabbi's team's results appeared in The *Astrophysical Journal*.

More information: E. Sabbi et al, Time-domain Study of the Young Massive Cluster Westerlund 2 with the Hubble Space Telescope. I, *The Astrophysical Journal* (2020). DOI: 10.3847/1538-4357/ab7372

Provided by NASA's Goddard Space Flight Center

Citation: In planet formation, it's location, location, location (2020, May 28) retrieved 30 April 2024 from https://phys.org/news/2020-05-planet-formation.html