Astronomers find a universal correlation that could unify the study of star formation

A research team led by Centro de Astrobiología (CSIC-INTA) has found an empirical relation that could allow unification of the different scales of star formation, from small scale individual stars in our neighborhood, to large scale whole galaxies at long distances.

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Star formation is one of the most important research fields in astrophysics. This process, in which gravitational instabilities cause the collapse of gas to form more compact structures and finally stars, encompasses a broad range of physical scales. From star forming galaxies on the large scale, to individual, young stars with envelopes and circumstellar disks on the smaller one, passing through intermediate scales that include giant molecular clouds and protostellar cores.

Since the last decades of the XXth century there is a well-known star formation relation for the intermediate-large scales called the Kennicutt-Schmidt Law. More recent versions of this law establish that the so-called star formation rate (SFR), which measures the pace at which stars are formed in a galaxy or a molecular cloud, is proportional to the amount of dense gas mass present in that galaxy or molecular cloud. The previous relation confirms that the star formation rate measured in galaxies is related to the mass of gas that is transformed into stars, which are located in the molecular clouds that those galaxies host, given that it is here where the material that will form stars is found.

On the other hand, at the small scale of star formation, it is also known that there is a correlation between the mass accretion rate, which measures the pace at which circumstellar gas falls on to a star in formation, and the mass of the protoplanetary disks that surround young stars. It is only since recently that this second correlation has been confirmed observationally, at least in the star forming regions where both parameters have been measured accurately.

In a work recently published in the Astronomy & Astrophysics journal and led by the Centro de Astrobiología (CSIC-INTA) researcher Ignacio Mendigutía, the authors have compiled, on the one hand, the available data for the SFRs and the dense gas masses of a sample of galaxies and a representative group of molecular clouds within our galaxy, and on the other hand, the available data for the accretion rates and disk masses of a representative sample of young stars, also in our galaxy. What they have found is surprising. A unique correlation emerges between the data compiled, encompassing no less than 16 orders of magnitude and relating very different physical scales: individual, young stars, molecular clouds, and galaxies. As pointed out by Mendigutía: “We have found a correlation between the pace at which gas transforms into stars and the dense gas mass directly associated to star formation. This is probably one of the widest empirical relations ever observed, given that it encompasses an enormous range of scales: from sizes of hundreds of thousands of light-years in galaxies, to sizes comparable to our Solar System in stars”.

The researchers suggest a “bottom-up” hypothesis to explain this discovery and propose future observations to test it. According to their hypothesis, the correlation in galaxies and molecular clouds would result from the smaller-scale relation between the individual stars hosted by them. “After the initial surprise, the fact that what we observe in individual stars correlates with whole galaxies is what one would expect if measurements on both scales are correct”, concludes Mendigutía.

About the CAB

The Center for Astrobiology (CAB) is a Joint Research Center of the Spanish National Research Council (CSIC) and the National Institute of Aerospace Technology (INTA). Created in 1999, it was the first Research Center of the world specifically devoted to astrobiological interdisciplinary research. In April 2000, CAB became the first Associate Member to NASA Astrobiology Institute (NAI). Its main objective is to study the origin, presence and influence of life in the universe. In addition to the understanding of the phenomenon of life as we know it (emergence, development, adaptability to extreme environments, etc.), it also involves the search for life beyond Earth (Exobiology) and Planetary Exploration and Habitability. Finally, the development of Advanced Space Technology and Instrumentation is also one of its main objectives.

CAB is a truly multi-disciplinary institute, hosting scientists specializing in a very wide range of topics as Biology, Chemistry, Geology, Physics, Genetics, Ecology, Astrophysics, Planetology, Engineering, Mathematics, Computer Science, etc., and has also several Support Units, such as an Education & Public Outreach Office, an Administrative Unit, and an extensive scientific Library.

Nowadays, CAB is hosting more than 120 researchers and technicians working on National and International Scientific Projects and participating in several European Networks. The CAB has developed the Rover Environmental Monitoring Station (REMS) for the mission Mars Science Laboratory (MSL), an environmental station on board NASA’s Curiosity rover, which is exploring Mars since 2012. Also, CAB is participating in the upcoming missions to Mars: TWINS instrument for NASA’s InSight mission, now in its cruise phase to the Red Planet, MEDA instrument for NASA’s Mars 2020 mission and finally RLS instrument for ESA’s ExoMars 2020 mission.

More information:

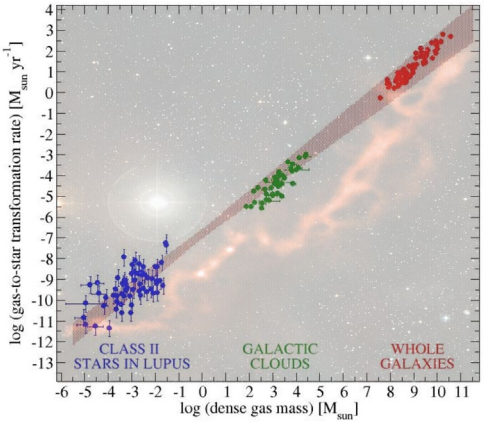

Figure. Graphic representation of the pace of transformation of gas into stars (vertical axis, in units of Solar masses per year) and the total dense gas mass (horizontal axis,

in units of Solar masses). One can see a correlation between the different scales: small (stars, blue dots), medium (molecular clouds, green dots) and large (galaxies, red dots). The background image is from ©ESO/APEX (MPIfR/ESO/OSO)/A.Hacar *et al.*/Digitized Sky Survey 2. Acknowledgments: Davide De Martin.

Scientific article in Astronomy & Astrophysics

A global correlation linking young stars, clouds and galaxies. Towards a unified view of star formation. I.Mendigutía, C.J.Lada y R.D.Oudmaijer

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