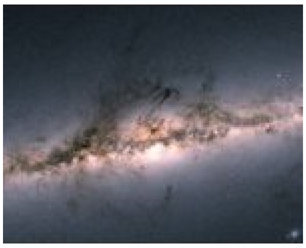
The mystery of the origin of the stellar halo of our Galaxy is being revealed



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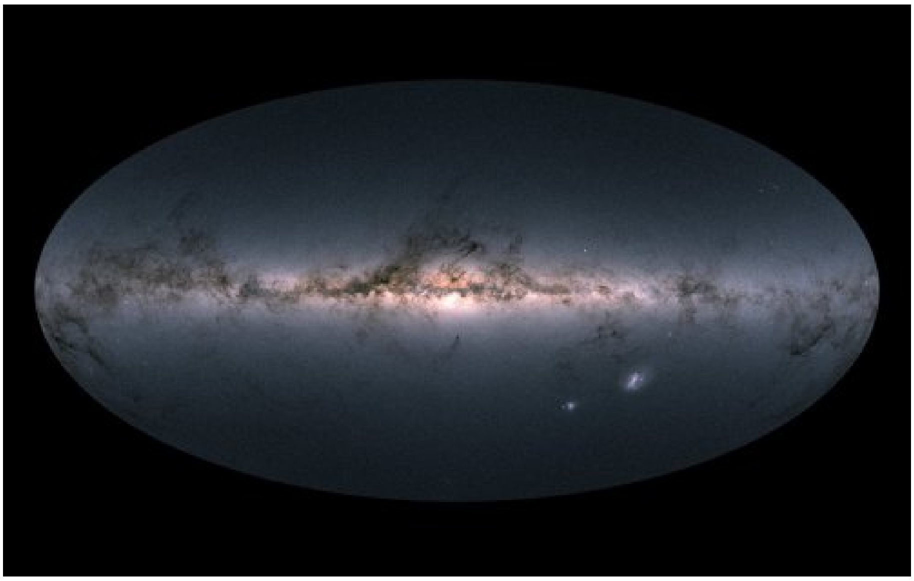
Observatoire de Paris - PSL Centre de recherche en astronomie et astrophysique

Thanks to data collected by the European astrometric satellite Gaia, the history of the Milky Way is being revealed. In a study published on November 20, 2019 in the journal Astronomy & Astrophysics, researchers from Paris Observatory decipher the composition of its stellar halo and rewrite the scenario on how stars were formed there.



La voie Lactée © *ESA*

Home to hundreds of billions of stars, our Galaxy consists of a galactic disc and a stellar halo surrounding it. The stellar halo is made up of very old stars with very low metallicities. Today, we know that not all the stars in our Galaxy were born there. Some stars were formed in other galaxies and were later "accreted" by ours.

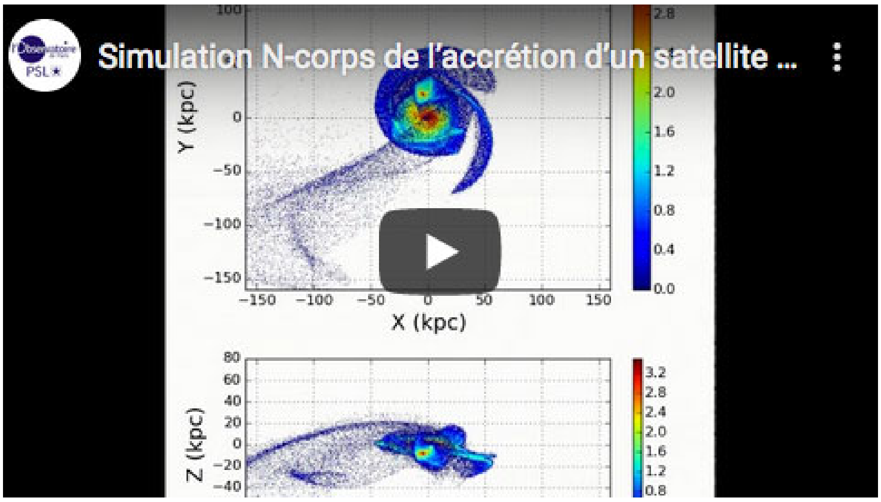
Data from the Gaia satellite have already revealed that a large part of the stars in the stellar halo probably belonged to a single galaxy that merged with the Milky Way. These stars constitute a significant part of the stellar halo. To explain the other component, the hypothesis was that stars had formed in the gas and dust cocoon of the proto-galactic nebula, during its rapid spherical collapse.

In an article published on November 20, 2019 in the journal Astronomy & Astrophysics, researchers from Paris Observatory at the Galaxies Etoiles, Physique et Instrumentation Laboratory (GEPI / Observatoire de Paris - PSL / CNRS), the Institut d'Astrophysique de Paris and the Max Planck Institute for Extraterrestrial Physics in Garching (Germany), broke this hypothesis after studying the halo stellar population.

To characterize the kinematics and chemistry of stars in the galactic halo, they combined astrometric data from the second catalogue of the Gaia satellite with the chemical abundances of the APOGEE spectroscopic survey.
The results of this study show that the halo is dominated by a population of accredited stars, representing about 60% of the stars with low metallicity (poor in metals).

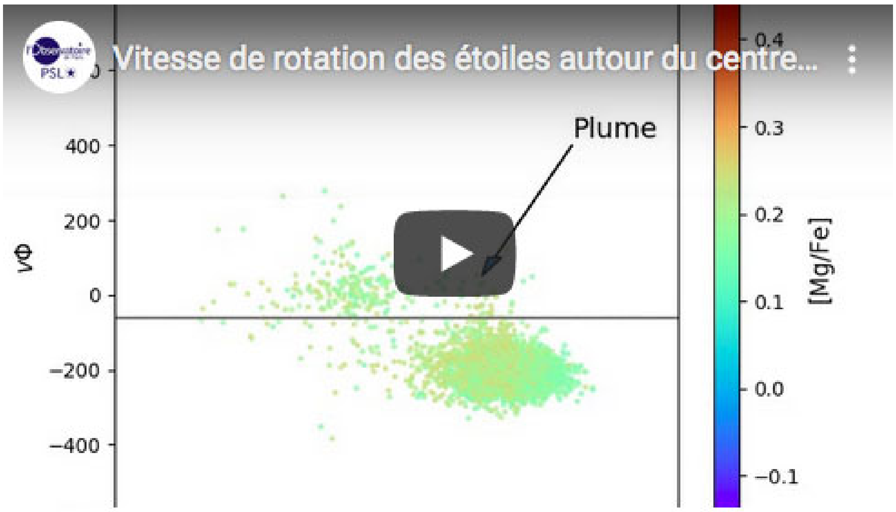
Surprise : the remaining 40% are old stars that must have formed within the galactic disc itself, not in the primitive halo.

But how did stars formed within the disc end up in the stellar halo of the Galaxy ? For the first time, these researchers reveal the stellar kinematic imprint left by this accretion event. The accretion "heated" the old galactic disc. This heating process has dispersed a significant fraction of disc stars in the stellar halo. This analysis is in line with the results of numerical simulations that had anticipated it.



Simulation N-corps de l'accrétion d'un satellite sur une galaxie type Voie lactée L'animation montre la réponse d'un disque galactique à l'accrétion d'un satellite. Dès le premier passage du satellite autour de la "Voie lactée", le disque chauffe, c'est-à-dire ses étoiles acquièrent de l'énergie cinétique, et il devient plus épais. Une partie des étoiles auparavant dans le disque est clairement éjectée à plusieurs kpc du plan galactique, dans le halo. A la fin de l'accrétion, le halo est constitué des étoiles accrétées du satellite, et des étoiles du disque, chauffées. Panneau du haut : vue de face de l'interaction ; panneau du bas : vue de tranche.) © *I. Jean-Baptiste, 2016, Thèse de doctorat*

The stellar kinematic imprint appears as a "plume" in the space that combines the rotational speed of stars around the galactic centre with their metallicity.



Vitesse de rotation des étoiles autour du centre galactique (vPhi) en fonction de leur métallicité ([Fe/H]). Les étoiles ont été groupées selon leur abondance en magnesium, relative au fer ([Mg/Fe]). Alors que, pour des rapports [Mg/Fe] < 0.2, les étoiles ont majoritairement une cinématique de disque (indiquée dans l'animation comme la région au dessous de la droite grise), à partir d'un rapport [Mg/Fe] >= 0.2 une "plume" d'étoiles apparait dans l'espace vPhi-[Fe/H], visible surtout à des métallicités autour de [Fe/H]=-0.3. Les étoiles dans la Plume ont des abondances chimiques typiques du disque, mais une cinématique de halo. Puisque le rapport [Mg/Fe] est fortement corrélé à l'âge des étoiles, en regardant des étoiles avec des rapports en [Mg/Fe] de plus en plus élevés, il a été possible de remonter le temps et d'utiliser la valeur du [Mg/Fe] à laquelle la Plume commence à être visible pour dater la fin de l'accrétion, il y a 9 à 11 Gyr.

Dating of the last major accretion in the Galaxy

By using this "plume", the researchers were able to date the end of the accretion episode. The last major accretion in the Galaxy occurred between 9 and 11 billion years ago.

The new scenario that emerges from this study suggests that the galactic halo is composed only of accreted stars and stars from the old galactic disc heated by the accretion.

This study raises questions about the origin of the Milky Way : does the primordial halo, without rotation, which was thought to have formed during an initial phase of spherical collapse of the proto-galactic gas cloud, exist ? The absence of stars clearly belonging to this component makes it more elusive than ever.

References

- The Milky Way has no in-situ halo other than the heated thick disc
- The Milky Way has no in-situ halo other than the heated thick disc. Composition of the stellar halo and age-dating the last significant merger with Gaia DR2 and APOGEE

