Machine learning yields a breakthrough in the study of stellar nurseries

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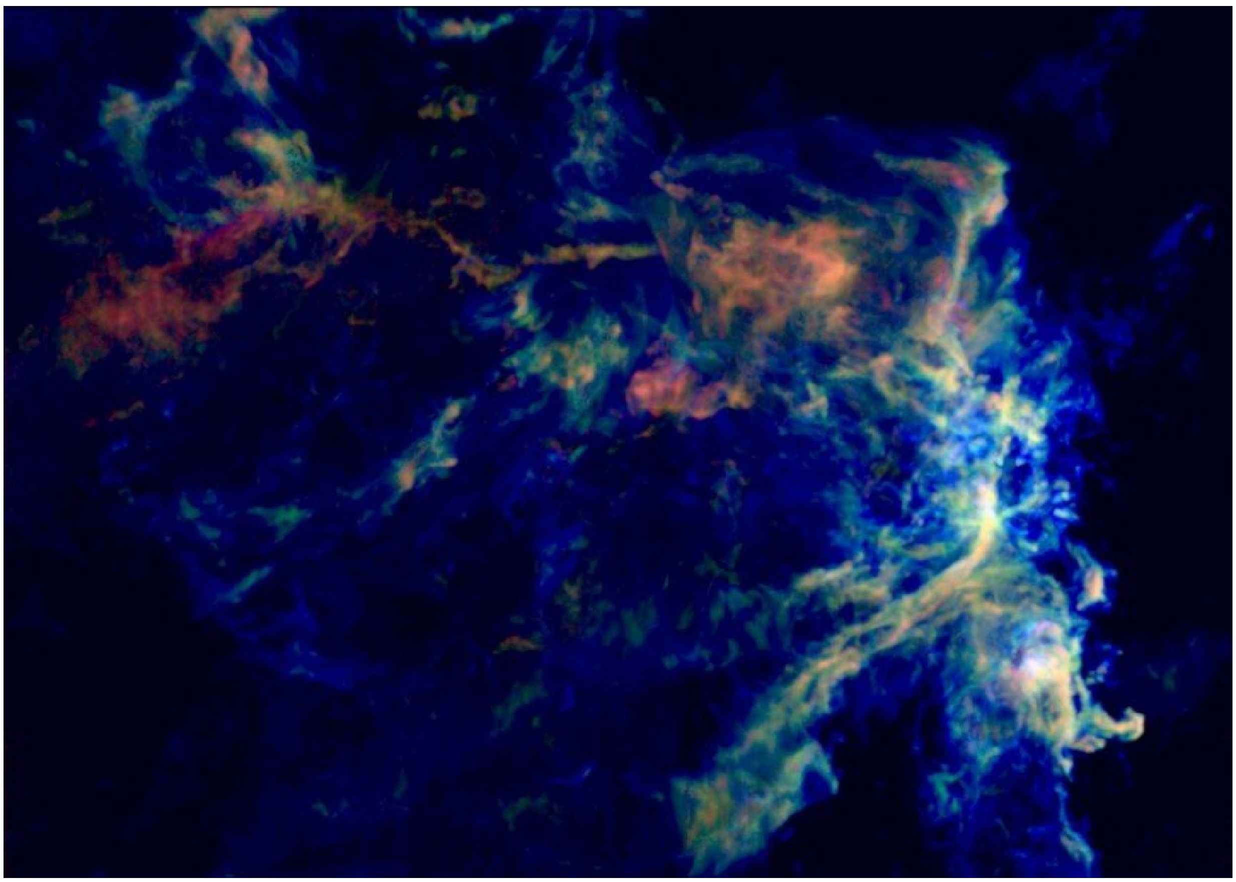

Emission of carbon monoxide in the Orion B molecular cloud Credit: J. Pety/ORION-B Collaboration/IRAM

Artificial intelligence can make it possible to see astrophysical phenomena that were previously beyond reach. This has now been demonstrated by scientists from the CNRS, IRAM, Observatoire de Paris-PSL, Ecole Centrale Marseille and Ecole Centrale Lille, working together in the ORION-B program. In a series of three papers published in *Astronomy & Astrophysics* on 19 November 2020, they present the most comprehensive observations yet carried out of one of the star-forming regions closest to the Earth.

The gas clouds in which stars are born and evolve are vast regions that are extremely rich in matter, and hence in physical processes. All these processes are intertwined at different size and time scales, making it almost impossible to fully understand such stellar nurseries. However, the scientists in the ORION-B program have now shown that statistics and artificial intelligence can help to break down the barriers still standing in the way of astrophysicists.

With the aim of providing the most detailed analysis yet of the Orion molecular cloud, one of the star-forming regions nearest the Earth, the ORION-B team included in its ranks scientists specializing in massive data processing. This enabled them to develop novel methods based on statistical learning and machine learning to study observations of the cloud made at 240 000 frequencies of light.

Based on artificial intelligence algorithms, these tools make it possible to retrieve new information from a large mass of data such as that used in the ORION-B project. This enabled the scientists to uncover a certain number of characteristics governing the Orion molecular cloud.

For instance, they were able to discover the relationships between the light emitted by certain molecules and information that was previously inaccessible, namely, the quantity of hydrogen and of free electrons in the cloud, which they were able to estimate from their calculations without observing them directly. By analyzing all the data available to them, the research team was also able to determine ways of further improving their observations by eliminating a certain amount of unwanted information.

The ORION-B teams now wish to put this theoretical work to the test, by applying the estimates and recommendations obtained and verifying them under real conditions. Another major theoretical challenge will be to extract information about the speed of molecules, and hence visualize the motion of matter in order to see how it moves within the cloud.

More information: P. Gratier et al. Quantitative inference of the H2 column densities from 3mm molecular emission: Case study towards Orion B, *Astronomy & Astrophysics* (2020). DOI: 10.1051/0004-6361/202037871

E. Bron et al. Tracers of the ionization fraction in dense and translucent gas. I. Automated exploitation of massive astrochemical model grids, *Astronomy & Astrophysics* (2020). DOI: 10.1051/0004-6361/202038040

Roueff et al., C18O, 13CO, and 12CO abundances and excitation temperatures in the Orion B molecular cloud: An analysis of the precision achievable when modeling spectral line within the Local Thermodynamic Equilibrium approximation. arxiv.org/abs/2005.08317

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