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JUPITER AND SATURN IMPACT DETECTION PROJECT AN EXAMPLE OF A COLLABORATIVE AMATEUR-PROFESSIONAL PROJECT

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1 Background and observations

Impacts of objects in the atmosphere of gaseous planets can be observed directly, in the form of luminous flashes caused by the combustion of the bodies at the time of entry into the atmosphere, or indirectly, by the traces of these combustion (dark traces, high in the atmosphere and thus brilliant in the absorption bands of methane).

Jean-Dominique Cassini followed the evolution of a complex dark spot on Jupiter throughout December 1690, a potential sign of an impact trace reminiscent of those left 3 centuries later by the fragments of comet P/Shoemaker-Levy 9.This last exceptional event was observed before the impacts, with the break-up of the comet into 21 bodies, during with the corresponding flashes, and after with traces visible for several months. The next impact was discovered as a trace 15 years later by Australian amateur Anthony Wesley (Hueso 2010).Then as described in Hueso & Delcroix (2018), 6 collisions have so far been discovered exclusively by amateurs in the form of flashes (see Fig. 1) in June and August 2010, September 2012, March 2016, May 2017 and finally August 2019. While the fragments of P/Shoemaker-Levy 9 were of the order of km in size, the 2010 trace came from a body of the order of hundreds of m, and the flashes (of 1 to 2s duration) between 10 and 20m.

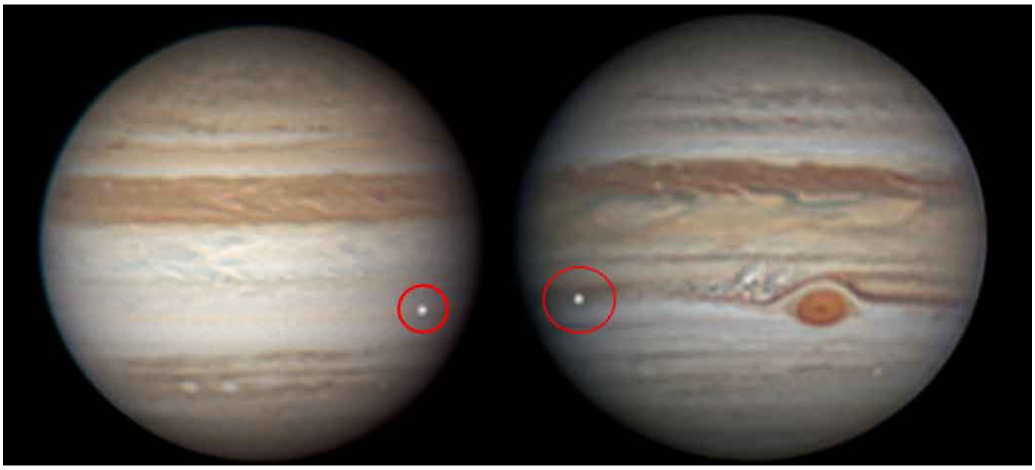

Fig. 1. First and sixth (and last) impact flashes discovered respectively by Anthony Wesley on June 3rd 2010, by looking at the screen during capture, and by Ethan Chappel on August 17th 2019, thanks to the use of the DeTeCt project software after the observation session.

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[3] 109 amateur astronomers from 20 different countries

2 DeTeCt project and software

Following the first amateur discoveries, the planetology team in Bilbao (RH) started in 2010 the development of a software to analyse video for impact flashes. In 2012, MD took over the development (DeTeCt software, see Fig. 2 on the left) to extend the objectives to the estimation of the frequency of the detected impacts, using the logs of the acquisition software used during the captures to date and characterise them, and generating an analysis log. This development has also been punctually supported by the Bilbao team thanks to Europlanet funding, and now counts 27 000 lines of code. It is shared on GitHub.

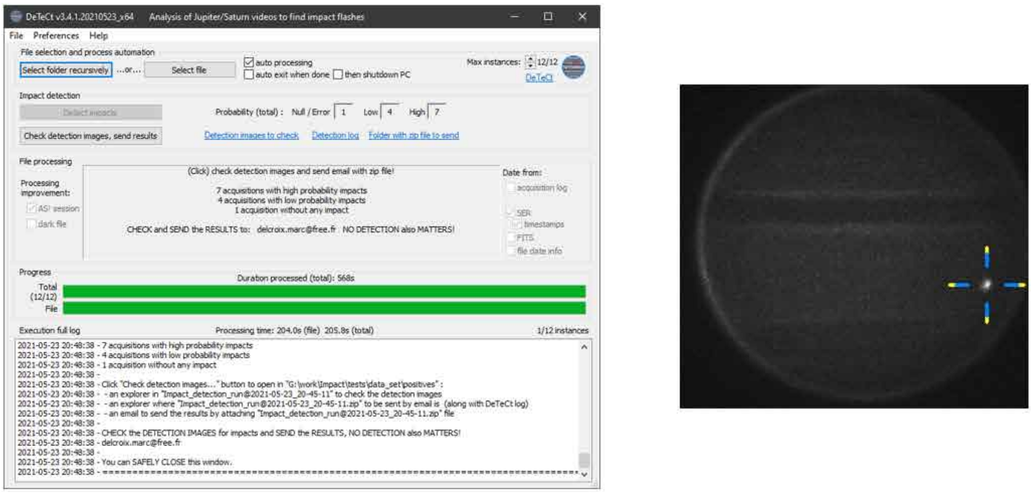

Fig. 2. On the left, the latest version of the DeTeCt software (regularly updated by MD). Right, detection image generated by the software (on the video of C. Go showing the June 2010 impact).

Video analysis works in two ways: A differential photometry algorithm looks for a localised and temporary increase in brightness over the frames that could be caused by an impact flash. A detection image is generated, consisting of each pixel's maximum value minus its average value over the entire video, to highlight a potential impact flash (see Fig. 2 right). The amateur himself analyses the results and detection images and sends them to the project (MD). The project confirms the results and takes them into account with a second consolidation software. The project web page (`http://http://www.astrosurf.com/planetessaf/doc/project_detect.php`) is automatically updated, showing the participation of each amateur, and the calculated estimate of the impact frequency for the planets Jupiter and Saturn (Delcroix 2017).

3 Project results

During its 9 years of existence, 109 participants from 20 countries (mainly in Europe, but also from the American continent, South Africa and Australia) have contributed to the project. Apart from contributions from the T1M at the Pic du Midi (F. Colas with amateurs) and Hampton University (K. Sayanagi), all of the contributions come from amateurs.

The data go back to 2003, and the 165,000 Jupiter videos which were analysed represent the equivalent of 6 full months of observation. Out of the 6 flashes detected, one (the last one in 2019) was only detected thanks to DeTeCt, and would have been missed without the use of the software, which demonstrates the interest of the project.

These data allow us to estimate the frequency of impacts on Jupiter at 13 impacts per year. As the data on Saturn, which is less observed, are much less numerous (28 days of observations), the estimate is currently that the impact frequency is less than 26/year (no impacts have been observed there so far, apart from suspicious traces in the rings observed by Cassini).

The calculated impact frequency for Jupiter is consistent with estimates made by other methods (see Fig. 3).

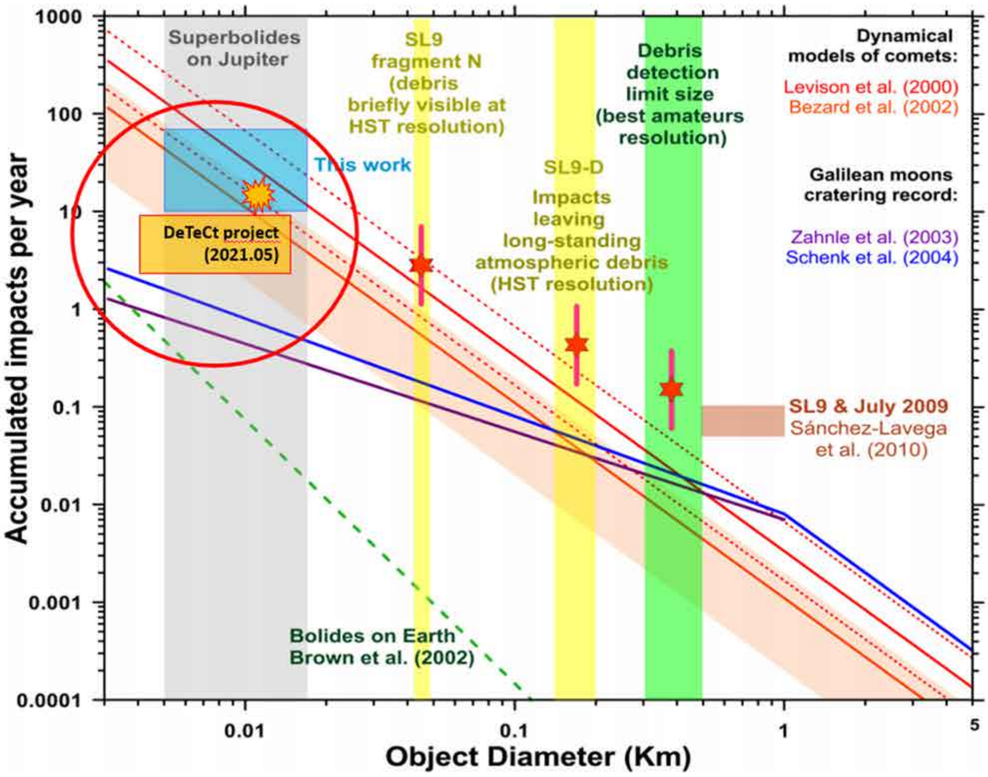

Fig. 3. Estimates by different methods of impact frequencies on Jupiter as a function of impacting body size from Hueso & Delcroix (2018).

4 Scientific value

The study of the light curves derived from amateur observations of impact flashes makes it possible to determine the energy released by the phenomenon by integrating the light intensity during the event (see Hueso (2013), Hueso (2018)). This enables us to estimate the size of the impacting body according to its possible density (which can range from a low-density comet-like body to an iron-like asteroid). On a quality observation such as the one shown in Figure 4, Sankar (2020) could identify simulations of impact light curves (varying as a function of angle of incidence and density) that best reproduce the observation showing the fragmentation of the body in the atmosphere.

These studies contribute to a better understanding of the population of small bodies crossing the Jovian orbit, and of the age of the surface of Jovian satellites as a function of their cratering. This project is a fine demonstration of the contribution of the amateur astronomy community to professional studies.

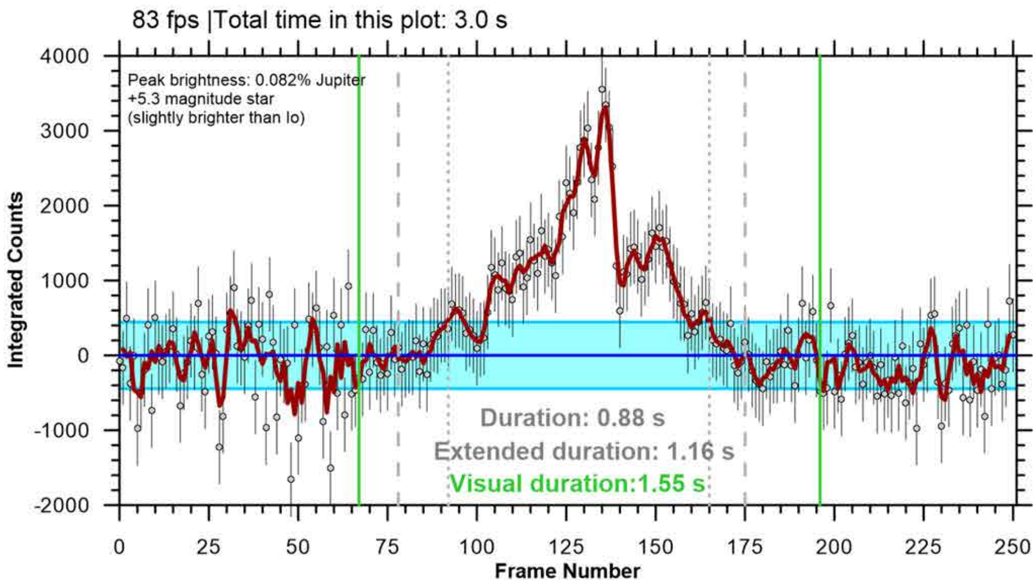

Fig. 4. Light curve of the flash discovered by E. Chappel with DeTeCt, from Sankar (2020). The quality of the observation makes it possible to distinguish secondary flashes.

5 Acknowledgements

We want to thank all amateur astronomers participating to the project.

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