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"IMPACTS" : IMPACTING METEOROIDS IN GIANT PLANET ATMOSPHERES CHARACTERIZATION SURVEY

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Résumé. All the planets of the solar system are subject to a meteoritic flux that can generate more or less threatening impacts. The frequency of these impacts and the size distribution of meteoroids and impactors are only known with a relative precision and mainly in the immediate vicinity of the Earth. However, it is essential to model precisely this flow in order to understand the formation of the solar system : except for the Moon, the dating of planetary surfaces rely only on crater counting. It is therefore essential to monitor the surfaces of giant planets with the best possible continuity to obtain a temporal coverage of these events that will make it possible to estimate the statistics of these impacts. For that, we propose to coordinate a campaign of observations of the impacts on Jupiter and Saturn by observing both flashes (objects greater than 5 m) and debris (objects greater than 100 m), associating amateur and professional astronomers at different latitudes to optimize the geographical coverage of these observations. The constitution of a participative database of observations of Jupiter and Saturn, as well as an alert system, will allow the coordination of observations of aerosol residuals immediately in reaction to the observations of the impact flashes on the surface of the giant planets. These observations will be supplemented by a thorough data digging such as old photographic plates to be digitized by the NAROO project for example. Automated processing of these observations (recent and older) will allow to estimate the meteorite flux at different points in the solar system and constrain the formation models of the solar system bodies (notably by making it possible to estimate the probabilities of survival of satellites and planetary rings during their formation and evolution).

Keywords: Impacts ; Meteorites ; Asteroids ; Ground observations : Jupiter, Saturn ; Participative database ; Collaboration : amateur and professional astronomers ; Surfaces ; Craterization

Project title : IMPACTS

Impacting Meteoroids in giant Planet Atmospheres CharacTerization Survey
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Characterization of the meteoroid flux across the Solar system.

1 Introduction

In 1994, the impact of comet Shoemaker-Levy 9 on Jupiter restarted the debate on the impact statistics around Jupiter. However, the unicity of the impact would prevent to estimate the infall rate with a good precision. The main characteristics of this event is that it was predicted more than a year in advance allowing numerous observers were able to join the ovbservation campaign. This fall allowed to characterize the effects on Jupiter and in particular the visibility of the aerosols deposited in the upper layers of the jovian atmosphere as a function of the impactor size.

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SL9 was a fragmented comet : its initial size is estimated between 1 and 5 km. The largest fragments reached several hundreds of meters. The following observed impact happened in 2009, observed by an amateur astronomer (A. Weysley) who detected dark traces on Jupiter's surface resembling the SL9 traces : the impactor was estimated to be about 100 m large. Other direct impact observations were made (in particular by amateurs) in 2009, 2010, 2012 and more recently in 2017 in Corsica : for these falls, the impactors were about 10 m large (from the measure of the meteor brightness that allows to derive the loss of kinetic energy, assuming a mean silicate density for these objects).

Such measures will allow to calibrate the craterization function of satellite and planetary surfaces that helps dating the objects of the solar system (and not just only in the Earth vicinity that is mostly constrained by Appolo's sample returns).

These observations require an optimization strategy to increase the geographical coverage and organize the necessary redundancy to compensate for weather uncertainties. The use of new cameras (Infrared High Dynamic cameras for instance) will allow to compete with some of the most recent space observations. `http://www.astrosurf.com/delcroix/PicDuMidi_T1M/PicduMidi_T1M_Europlanet_workshop.htm`

We sollicitate the participation of amateur astronomers to increase the coverage of the impact events on Jupiter and Saturn : it is primordial to gather impact observations in an international participative database able to relay the observation alerts so that other observers can dig in their observations and provide complementary data.

2 Context

The meteoroid flux is only well known in the Earth environment (Earth and Moon). However, modeling giant planet subsystems requires a more precise estimation of the meteoroid flux in the outer solar System : this is in particular necessary for the sudy of rings survival and outer planet satellites formation.

3 Aims

For the past few years, amateur and professionnal observers were able to detect a few impact flashes in the upper layers of Jupiter's atmosphere, due to (¿10 m)-sized meteoroids. In addition, we estimate that the resulting aerosols deposited in the upper layers of the giant planet atmospheres remain visible for a few days/weeks. This will allow possible indirect observations of such impacts even a few days after the events. Based on the observations at such flashes and aerosol remains at the surface of the Solar system giant planets, we intend to estimate the meteoroid flux at Jupiter and Saturn, and model this flux as a function of the distance to the Sun.

4 Methods

We will organize an observational survey of Jupiter's and Saturn's surface in order to estimate the flux of meteoroids at their locations and the size of the impactors. While a few such events were recorded by chance in the last few years, we expect that a thorough continuous observation campaign of Jupiter's and Saturn's surface will allow to determine the meteoroid flux at 5.2 and 9.1 AUs. It appears that such impacts release aerosols in the planet atmsosphere that are able to remain visible from Earth for a few weeks with a Methane filter. Therefore, repeating observations every month will provide a good estimation of that flux.

5 Observations

We will observe Jupiter and Saturn from the T1M at Pic du Midi (PI : Francois Colas, who is also co-I in this project), the 120-cm and 152-cm telescopes at Observatoire de Haute-Provence. Occasional former planetary missions data may be used to characterize impactors and calibrate impactor sizes from ground observations. In addition to observing by ourselves (Baillié, Colas, Birlan), we will coordinate with the usual IMCCE observation programs (satellites, GaiaFun, ...) to obtain regular data of Jupiter and Saturn between our periods of observations. Finally, we will create a team of professional and amateur observers to increase our coverage of these events over at least half a period of Jupiter.

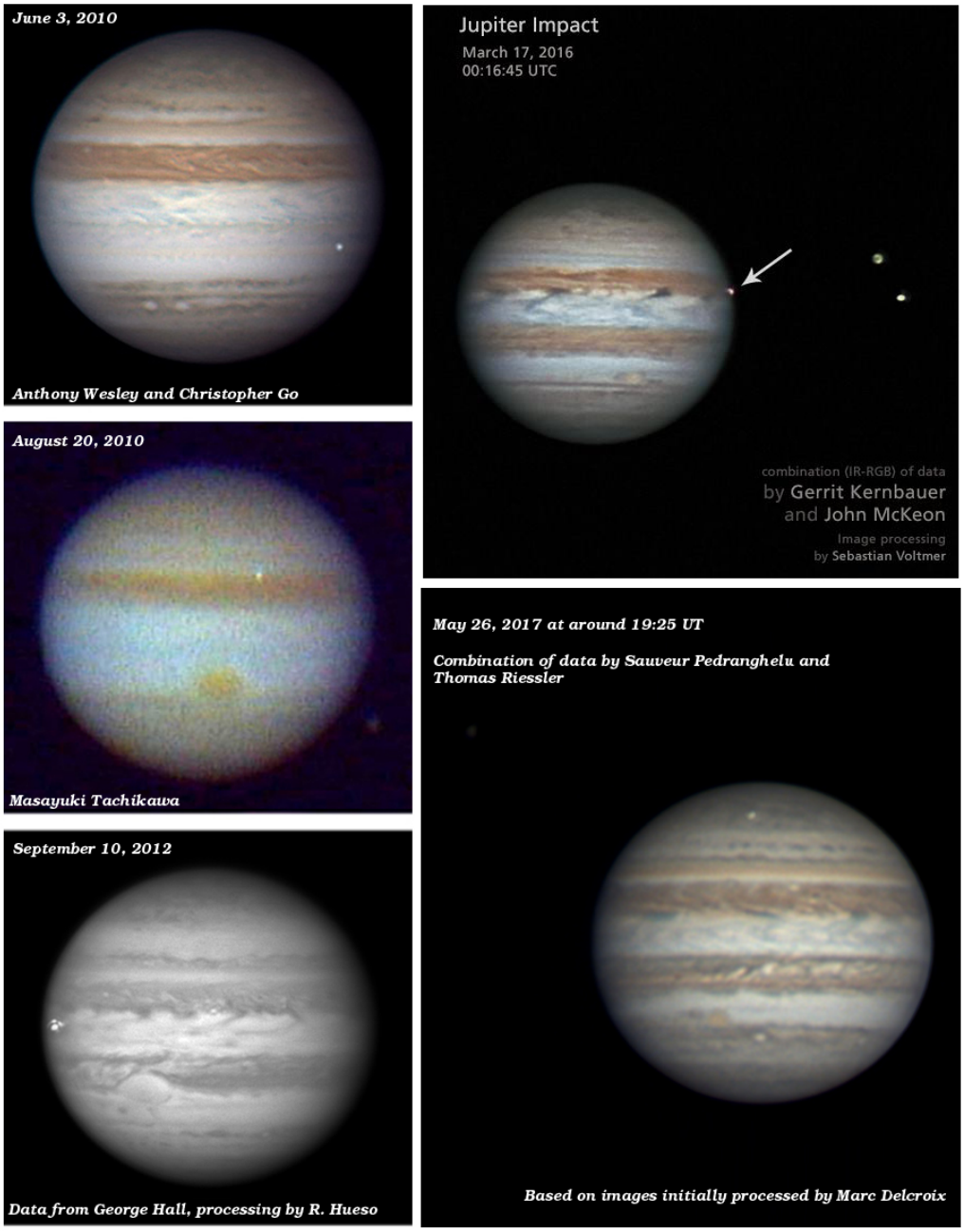

Figure 1. Observed luminous flashes due to the impact of meteoroids in Jupiter's atmosphere since 2009.

6 Consequences

A precise estimation of the meteoroid flux at various planet locations will allow to derive a model of the present flux as a function of the distance to the Sun. Such a model will help constrain the scenarios of formation of the giant planet rings and satellites, and in particular their age : it may help calibrate crater counting methods for the outer planet icy satellites and quantify the ballistic transport inside Saturn's rings.

7 Funding proposals

— Europlanet NA1 Workshop Proposal (accepted).
— «ePARADISE» ANR funding (under review) : Dedicated high dynamic IR camera at Pic du Midi.

— CS-OBSPM and INSU fundings (in prep.) : PhD thesis subject (adv. Colas & Baillié)

Kévin Baillié is a postdoctorate researcher at IMCCE – Paris Observatory, funded by a CNES fellowship. During his PhD in UCF (Orlando, USA), he worked Cassini UVIS data to characterize and model Saturn's rings and satellites. He is also a co-I of the "ePARADISE" project that aims at developing an Infrared Adaptative high dynamic camera for the T1M telescope at Pic du Midi (French Pyrénées).

Francois Colas, is a Research Director at CNRS, PI of the FRIPON project and of the T1M telescope at Pic du Midi. His expertise in solar system objects observations will be a great benefit for the organization of the observation campaign and the formation of amateur astronomers in the frame of this survey.

Marc Delcroix (Station de Planétologie des Pyrénées), is responsible of the DeTeCt program, expert in Jupiter flash detections.

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