# OAG JUPITER PROJECT 2007+

SECOND REPORT

January 2019

**(SHORT VERSION WITHOUT TABLES III & IV)**

# ZENOGRAPHIC LATITUDES OF JUPITER BELTS

## Part I: Reference Positions 1907 – 2018

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## 1. Introduction

Jupiter's atmosphere most characteristic features are the dark belts and the bright areas. These are distributed latitudinal in the entire disk. Since the first accurate position measurements obtained with micrometers at the end of the 19th century, until the current digital images, the latitudes' belts are very stable. There are some exceptions to this rule, but generally, the observed changes are due to the apparent effect caused by weakening or strengthening their intensities. The structure and dynamics of these gaseous bands depend on the location of the general currents and the jet-stream currents that define the different zonal domains. As it happens on Earth, notwithstanding in every sense the apparent differences, these structures definitions are the manifestation of Jupiter's climate. The zonal circulation is characterized by currents E/W, with an atmosphere rotation average of 9 h 55.5m. Belts and dark spots are warmer than the bright spots areas, that are colder. The Great Red Spot (GRS) is the coldest structure, all the bright and dark spots are vortices located between jet-stream currents. Belts and spots are produced by the emerging inside heat. The darkening of the limbo indicates the presence of the gaseous wrap in which sunlight is absorbed and dispersed. Its main elements are Hydrogen, Helium, Ammonia, Methane and simple Hydrocarbons. The clouds are basically formed by Ammonia ice crystals.

This study' goal is to provide the observer useful location references of Jupiter's belts, allowing comparing it to the reader's own results to place them correctly. Although for the large Tropical and Equatorial belts, the historical identification is very obvious, they are subjected to strong variations without a regular period, in which they disappear, reappear, and multiple belts are formed, later to return to the more usual disposition. In Table I variations of identification can be perceived, I had to keep them to show a certain range of possibilities. In most cases, we can relate them together among them thanks to latitude measurements. As we move away from these low-latitude Tropical and Equatorial domains, ambiguity increases, being it maximum near the Polar Regions. Under excellent observation conditions, in higher latitudes (greater than 48 ° N/S) longitudinal traces that are let to be seen may or not be considered belts. Currently, digital images have allowed registering numerous traces as a way of fragments of belts, only glimpsed visually in previous decades and centuries. Although we have established a coherent nomenclature, the classification as belts is only indicative. The observations here are fundamentally morphological; the precise observation must be done by determining the rotation periods of the details observed in them. The periodic publication of the Zenographic latitudes, beyond facilitating the observational task, is also of interest as an indicator of possible large-scale climatic changes in Jupiter. As it can be seen in this compendium of measurements, the historical data is far from complete. Fortunately, this scenario has changed favorably due to the current high capacity of Pro-Am equipment, to obtain high resolution images with relatively modest instruments. Followed by observers' networks scattered around the world, the constant patrolling of the planet is assured, and also the continuity of surveillance over the zenographic latitudes.

This is a non-professional project with the purpose of encouraging and facilitating the observation of Jupiter to all those who have their own team, collaborating and participating in international campaigns. Pro-Am specialists from around the world meet periodically to discuss experiences and exchange work proposals. Currently, observing Jupiter is a good example of shared science.

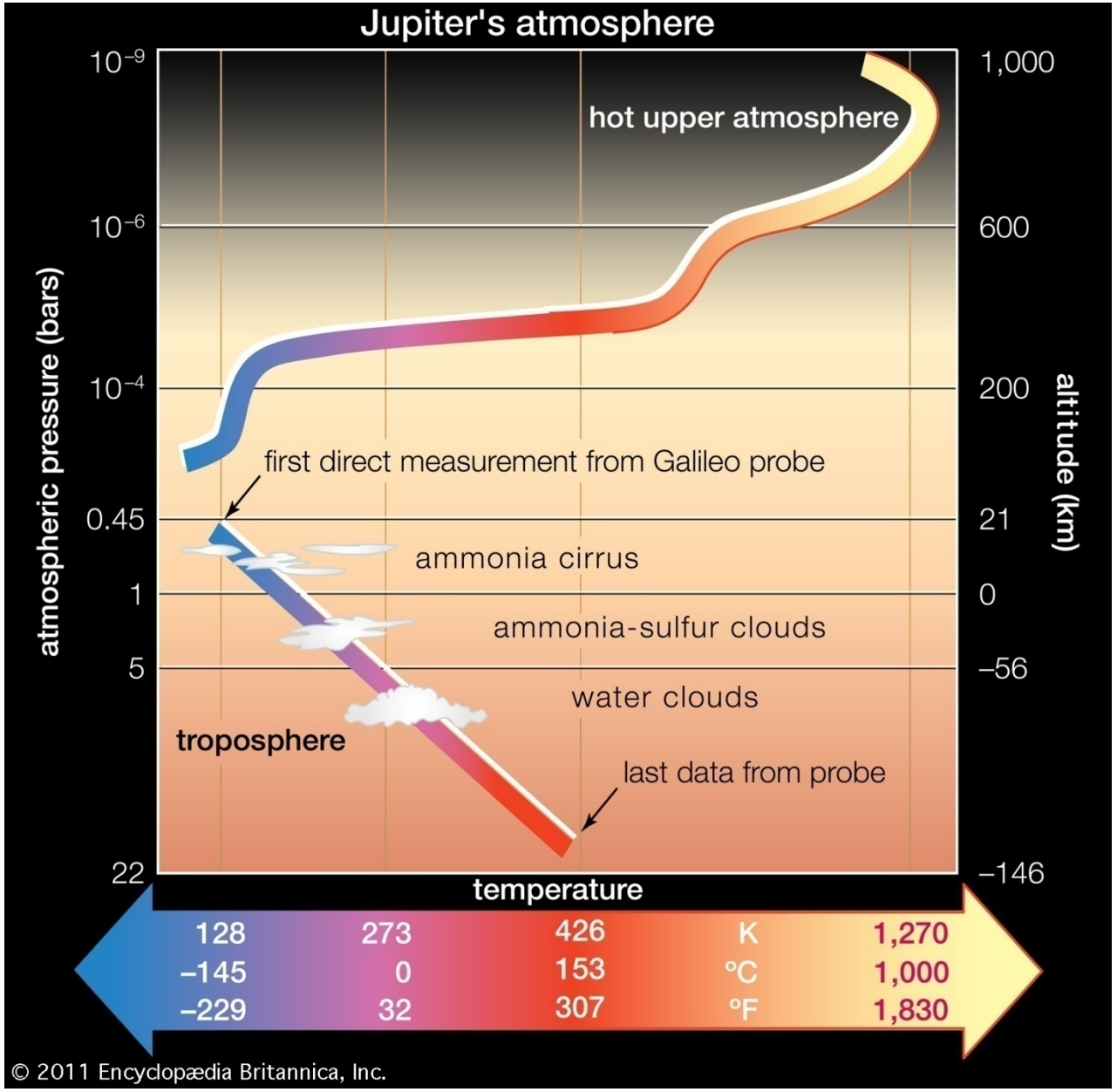


**Fig.1** The Jupiter's atmosphere

## 2. OAG Jupiter Project

The Jupiter images obtained regularly with medium and high resolutions initiated by J.A.Soldevilla (JAS, Canyellas Observatory, Barcelona) from 2007, aroused the interest of the OAG to maintain its cataloging, classification and subsequent analysis. In 2014, the images gathering process and preparing a special section on the OAG website began. The images already treated by JAS are disseminated in the first instance by the author on the Jupiter Section web of ALPO-Japan, forming part of the international planet monitoring. The JAS images were listed and sorted chronologically. All obtained dates / times were checked, correcting errors in UT, typographical or others in a small percentage. For each image, the MC Lengths of Systems I and II, the Heliocentric Longitude, as well as the instrumental data are provided. On each one of them you can access the published image. This system allows to select the images by CM, being easy to choose those that we are interested in studying. We can compare like this, the same regions of the planet in different apparitions (it is called apparition to the period of visibility of the planet centered on its Conjunction).The JAS's observations at the time of this study closure range from May 30, 2007 (HL = 254 º) to August 2, 2018 (HL = 235 º), being one year after completing a revolution around the Sun. The JAS's observations are complete in this period except for the years 2011 and 2012 when no images were taken. It was the time when the observatory changed instruments, replacing the Newton reflector of 250mm F / 6, with the current Schmidt Cassegrain reflector of 356mm F/10 (Celestron C-14). JAS's recent participation in international meetings placed him among a select group of Jupiter observers. In Table III it can be seen all the images obtained by JAS. You can open them with a simple mouse click in OAG web site Jupiter Section. We can see the technical evolution throughout these 11 years of work, from the first results, even very modest, improving season after season to the excellent current standards.

**OAG Jupiter Project 2007+** is based primarily on JAS's observations, which are supplemented with other sources. Some high-resolution images obtained by international observers and published by ALPO-Japan are used as reference in the measurements. They also allow to solve doubts about the identification of details and to know the margin of error with which the author works. Only two selected images have been used for this, one from Foster (South Africa) and another from Vidal (Barcelona).The total JAS's classified images between 2007-2018 in this project has been 298. In 2018 T.Tobal (TOB) obtained a series of images at primary focus from the OAG, using the Schmidt Cassegrain reflector of 288mm F / 10 (Celestron C11) in integral light and Baader CH-4 / 7nm filter. These low-resolution images also allowed useful measurements of the main details, being perfectly compatible with those obtained with larger instruments. This sub-project was called **Jupiter Prime Focus Project_2018** (see Table IV), ending with the registration of 105 images (12 of them in the CH-4 band) between April 18 and May 11 (HL = 227º-228º). In this case the planet was followed for an interval of 2 to 4 hours, showing the details at different distances from the CM. The direct contribution of images in the measurement of the zenographic latitudes reaches a total close to 400.

**Fig.2** Left: J.A.Soldevilla taking pictures / Right: T.Tobal working with *WinJupos* software

## 3. Preliminary studies: Latitude measures of Northern Belts 2007-2014

The first systematic measurement test was performed on JAS images between 2007 and 2014.The objective was to test the working methods offered by the WinJupos application, widely used by all specialists. Concentrated in the exclusive measurement of the Zenographic latitudes (LZ), we chose the zone included to the North of the NTB, the historically the least studied. All the JAS images were analyzed, obtaining the mean values for the belts identified in 2007-2014. Subsequently, similar studies published in Strolling Astronomer (ALPO, USA) between 1985 and 2007 were selected (see bibliography).The objective was on the one hand the control of errors and if the results were consistent, obtain a temporary series on a large scale. It followed, then, the criteria established by Peek and Rogers in his books already classic references. The results have been published on the OAG website in the corresponding section. In addition to the experience gained, we have already glimpsed at the difficulty of identifying these high-latitude bands.

One of the most meticulous studies in this field conducted in the 1970s, was carried out by the team of the Jupiter section of the AAS (Sabadell, Barcelona), coordinated by J.Mª.Gómez. The measurements were made from 1,000 photographs taken from the Teide Observatory (Canary Islands) with the 400mm aperture solar telescope. Quoted by Rogers (1995) is an excellent reference of the zonal distribution of Jupiter in 1975-76 (see references). Its author continues to be one of the most recognized specialists on this planet, analyzing and publishing results in the most prestigious international Pro-Am teams.

The compendium of all the sources consulted determined the average values of the northernmost Jupiter belts, marking the method to follow for the global analysis that we propose in this project. He also showed us that the sources, although diverse, were perfectly compatible. The relative apparent stability in latitude of Jupiter's belts greatly facilitates this issue.

## 4. Average Zenographic Latitudes (β") 1907-2018

Table I summarizes the average positions established for three periods 1907-1937 (Rogers 1995), 1950-1979 (Gómez 1976, Rogers 1995) and 1975-2018 ( Gómez 1976, Akutsu 1985, Schemude, Rogers 1995, 1989-2007 and Tobal-Soldevilla 2007- 2018).For each belt, the average value of the Zenographic latitude and the standard deviation is given, when there are no observations specified with the acronym ND (No Data). Whenever possible, the latitudes have been adjusted in main reference to the nomenclature provided by Gómez (1976). In cases where there seems to be no correlation, the author's original designations have been left.

This table allows us to easily check the stability of the zonal positions in the last 111 years, that despite the known episodes of disappearance and reappearance, changes of intensity and disturbances that suffer certain details, their habitual or canonical disposition is recovered (Rogers expression 1995).I hope that this compendium allows to place every detail observed in its corresponding belt, insisting that it is a morphological classification, that is, establishing the nomenclature by alternating dark belt and bright zone from NPR to SPR.

Table II summarizes the average positions established for the period 1907-2018 from all sources and observations described in the text.

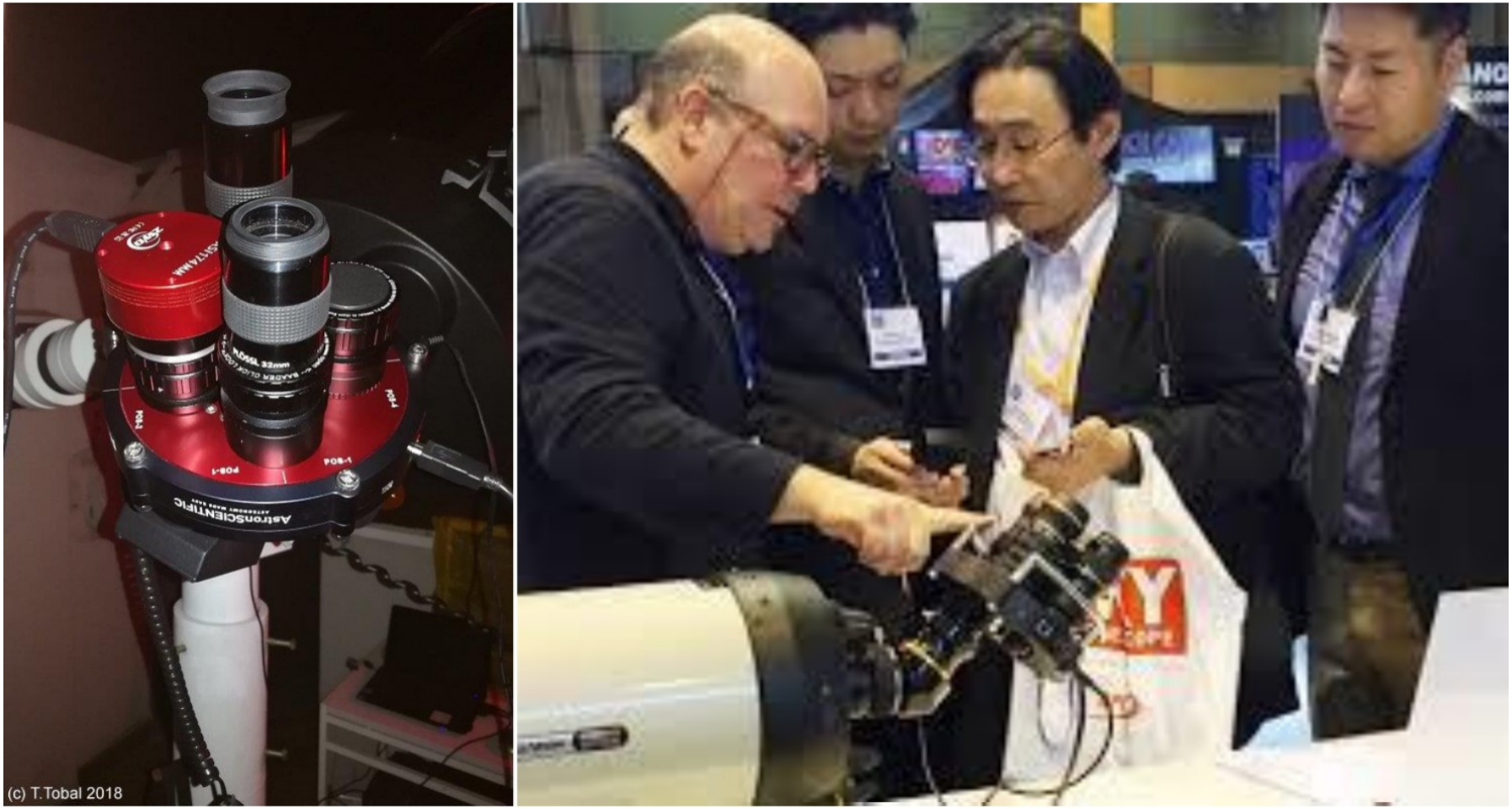


**Fig.3** Collaboration of ***AstronScientific*****:** *Rotarion* wheel for visual and digital observation. Prototype installed in the OAG on the Celestron C-11 telescope courtesy of its designer Álvaro Martínez. ASI-174MM camera and various eyepieces during the development of **Jupiter Prime Focus Project_2018**. In the image on the right, Álvaro Martínez showing the device at NEAF 2016 (New York, USA).

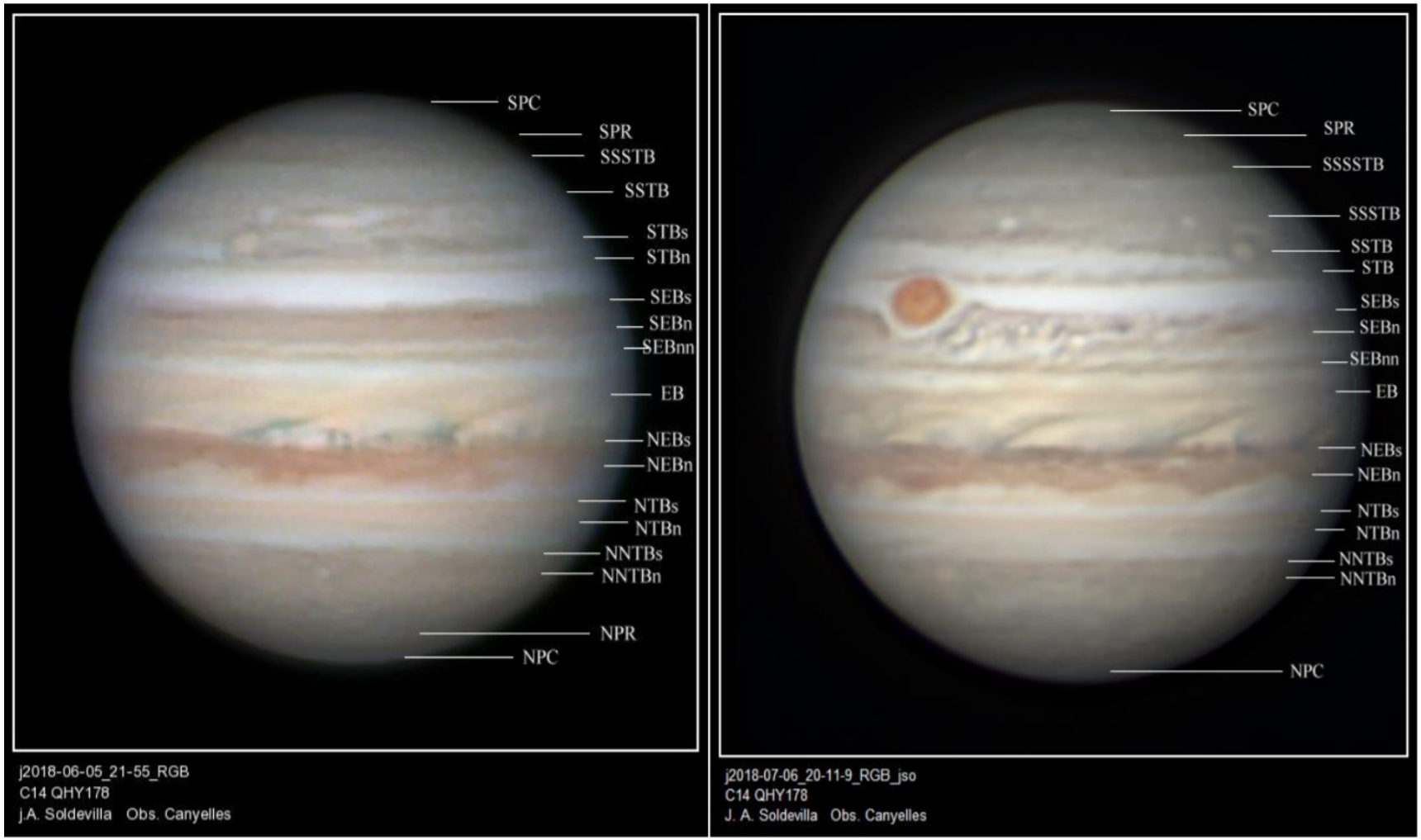


**Fig.4** Preliminary identification work by T.Tobal of the belts on images obtained by J.A.Soldevilla.

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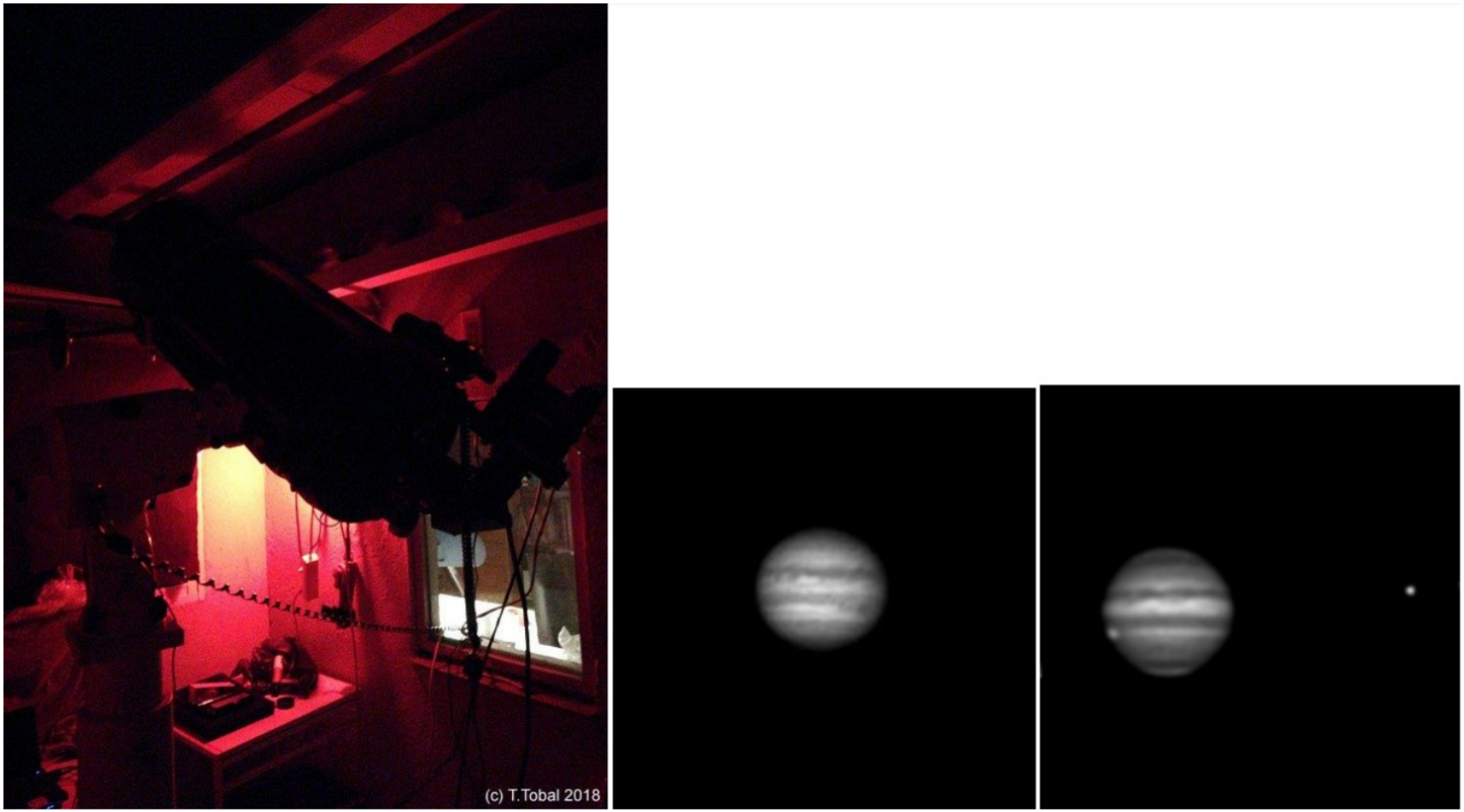


**Fig.5** Observation session in OAG. C-11 Telescope + *Rotarion Wheel* by AstronScientific.

Images examples taken at primary focus in integral light and with filter Baader CH-4 / 7nm by T.Tobal in april-may

**(OAG Prime Focus Project_2018)**

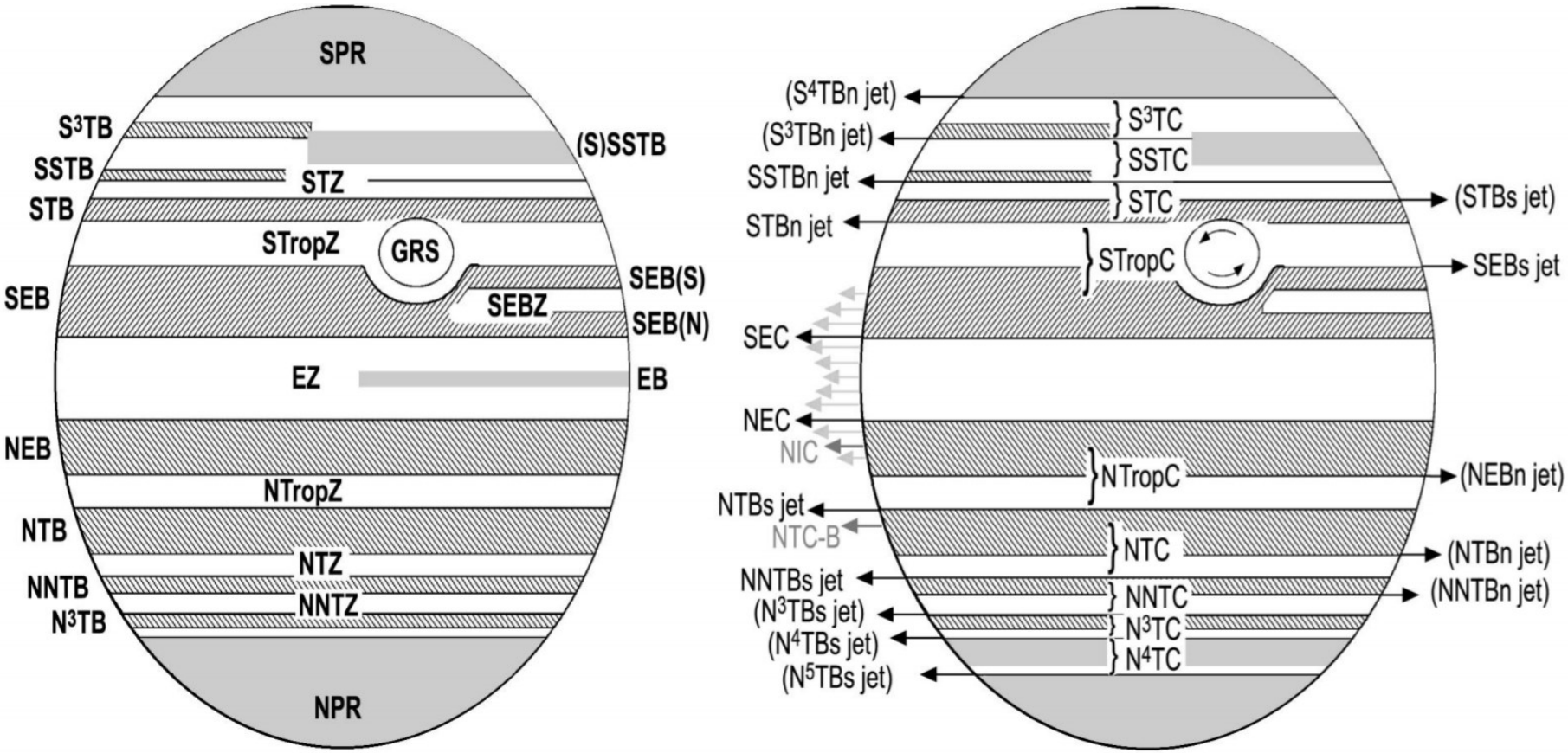


**Fig.6** Standard nomenclature for Jupiter belts, bands and currents (Rogers 1995)

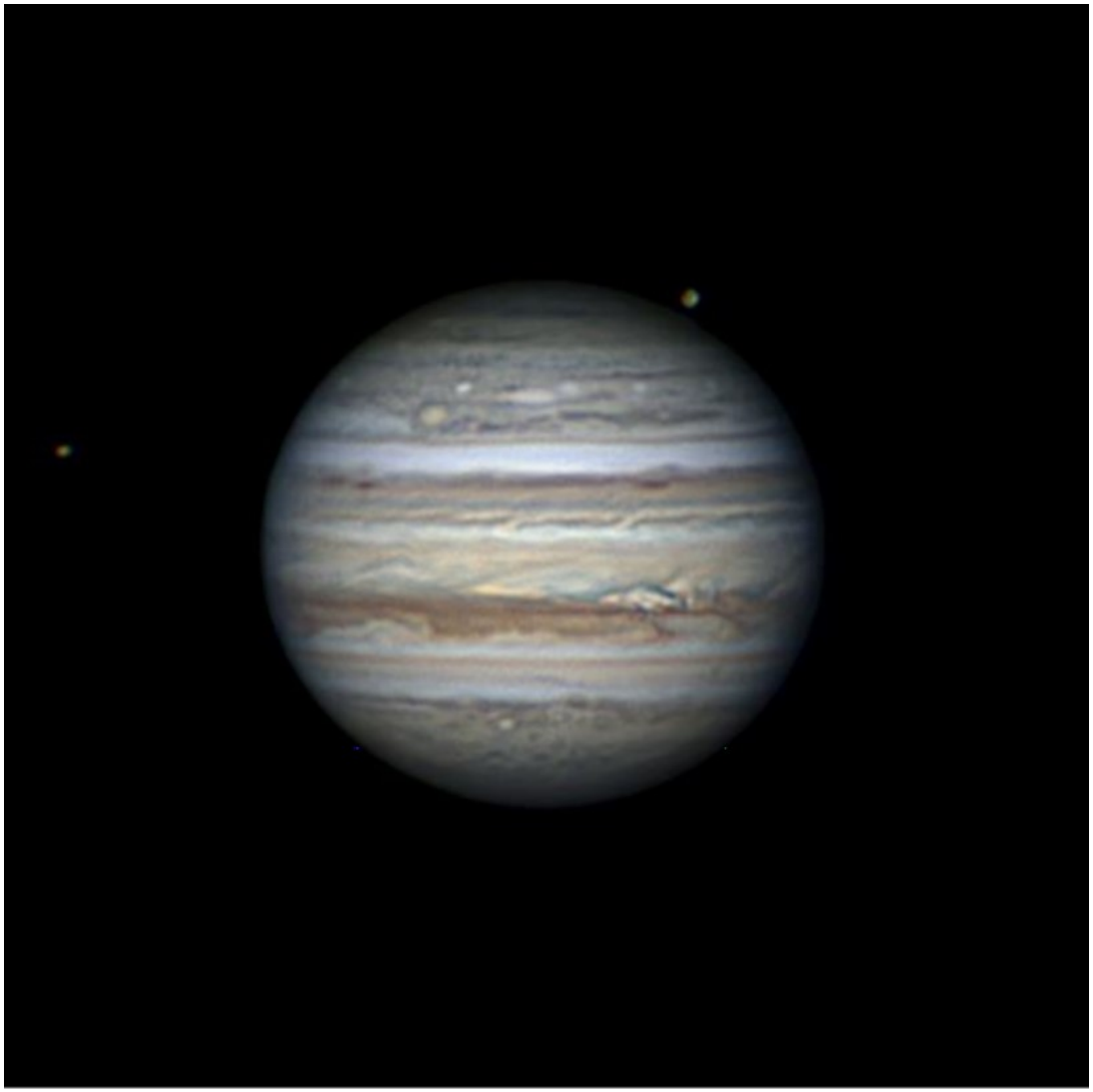

**Fig.6** High resolution image by A.Vidal (Barcelona) 20180531 22h50m53seg UT. CMI= 272,3º CMII= 53,5º CMIII= 284,1º Diam: 44”,1 Mv -2,5

**Tabla I: Comparative Reference Positions of Jupiter Belts**

**Zenographic Latitudes**

| BELT | ß" 1907-1937 | σ st | ß" 1950-1979 | σ st | ß" 1975-1976 | σ st | ß" 1975-2018 | σ st |
|---|---|---|---|---|---|---|---|---|
| NPR | ND | ND | ND | ND | ND | ND | +65.0 | 1.2 |
| N5TB-N | ND | ND | ND | ND | +59.8 | 0.3 | +59.9 | 0.1 |
| N5TB-C | ND | ND | +57.0 | ¿? | +56.7 | 0.2 | +57.5 | 0.5 |
| N5TB-S | ND | ND | ND | ND | +51.8 | 0.4 | +52.7 | 1.6 |
| N4TB-N | ND | ND | ND | ND | ND | ND | ND | ND |
| N4TB-C | ND | ND | ND | ND | +50.9 | 0.2 | ND | ND |
| N4TB-S | +48.0 | 0.8 | ND | ND | +48.3 | 0.2 | ND | ND |
| N3TB-N | +47.0 | 1.0 | +47.0 | 1.0 | +46.5 | 0.1 | +47.6 | 0.6 |
| N3TB-C | ND | ND | +44.9 | 1.0 | +43.7 | 0.2 | +44.8 | 1.2 |
| N3TB-S | ND | ND | +42.7 | 1.0 | +41.7 | 0.2 | +41.1 | 0.8 |
| N2TB-N | ND | ND | +39.1 | 0.7 | +39.2 | 0.3 | +38.7 | 0.8 |
| N2TB-C | +38.1 | 1.0 | +37.4 | 1.1 | +37.4 | 0.3 | ND | ND |
| N2TB-S | ND | ND | +35.8 | 1.0 | +35.6 | 0.2 | +35.3 | 0.9 |
| NTB-Nn | ND | ND | ND | ND | +33.9 | 0.4 | ND | ND |
| NTB-Nc | ND | ND | ND | ND | +32.4 | 0.4 | ND | ND |
| NTB-Ns | +30.6 | 1.9 | +31.0 | 0.8 | +31.2 | 0.1 | ND | ND |
| NTB | ND | ND | ND | ND | +27.9 | 0.4 | +29.3 | 0.8 |
| NTB-Sn | +25.1 | 0.6 | +25.1 | 0.6 | +26.3 | 0.2 | +26.8 | 0.8 |
| NTB-Sc | +24.5 | 1.6 | +23.9 | 0.8 | +24.5 | 0.3 | +24.1 | 0.6 |
| NTB-Ss | +22.4 | 1.0 | +23.3 | 0.8 | +22.8 | 0.3 | +20.2 | 0.7 |
| NEB-N | +17.5 | 2.7 | +18.1 | 2.2 | +17.3 | 0.3 | +16.4 | 0.9 |
| NEB-C | ND | ND | ND | ND | +12.4 | 0.3 | +12.8 | 0.5 |
| NEB-S | +7.1 | 1.0 | +7.5 | 0.6 | +7.0 | 0.4 | +9.1 | 1.0 |
| EB-Nc | ND | ND | ND | ND | +1.5 | 0.1 | ND | ND |
| EB-Sn | ND | ND | ND | ND | -1.5 | 0.2 | ND | ND |
| EB-Sc | ND | ND | ND | ND | -3.1 | 0.1 | -2.8 | 0.4 |
| EB-Ss | ND | ND | ND | ND | -4.7 | 0.1 | ND | ND |
| EB | ND | ND | ND | ND | ND | ND | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SEB-Nn | ND | ND | ND | ND | -6.9 | 0.2 | ND | ND |
| SEB-Nc | ND | ND | ND | ND | -7.8 | 0.3 | ND | ND |
| SEB-Ns | ND | ND | ND | ND | -8.5 | 0.4 | -8.6 | 0.7 |
| SEB-N | -+6.9 | +1.1 | -7.0 | 0.9 | ND | ND | ND | ND |
| SEB-Sn | ND | ND | ND | ND | -9.0 | 0.3 | ND | ND |
| SEB-Sc | ND | ND | ND | ND | -11.9 | 0.2 | ND | ND |
| SEB-Ss | ND | ND | ND | ND | -12.3 | 0.2 | -13 | 0.6 |
| SEB-(S) | ND | ND | ND | ND | ND | ND | ND | ND |
| SEB-Sn | -18.7 | 0.8 | ND | ND | -16.9 | 0.3 | -17 | 0.6 |
| SEB-Sc | ND | ND | -20.7 | 1.1 | -20.1 | 0.2 | -19.5 | 0.9 |
| SEB-Ss | ND | ND | -24.8 | 0.3 | -23.7 | 0.2 | ND | ND |
| SEB-(SS) | ND | ND | ND | ND | ND | ND | ND | ND |
| SEB-S | ND | ND | ND | ND | ND | ND | ND | ND |
| STB-N | -26 | 1.2 | -26.8 | 1.2 | -26.1 | 0.3 | -27.3 | 0.7 |
| STB-C | -28.9 | 0.9 | -30.2 | 0.7 | -30.1 | 0.4 | ND | ND |
| STB-S | -31.3 | 1.3 | -33.3 | 0.9 | -33.7 | 0.4 | -32.1 | 0.4 |
| S2TB-N | ND | ND | -36.3 | 0.6 | -36.5 | 0.5 | -35.8 | 0.8 |
| S2TB-C | ND | ND | ND | ND | -39.2 | 0.3 | -38.7 | 1 |
| S2TB-S | -41.4 | 2.3 | -41.9 | 1.8 | -41.7 | 0.6 | -41.9 | 0.4 |
| S3TB-N | ND | ND | -42.1 | 1.1 | -44.6 | 0.5 | -44.3 | 0.6 |
| S3TB-C | ND | ND | ND | ND | -47.4 | 0.4 | -47 | 0.8 |
| S3TB-S | ND | ND | -46.6 | 1.3 | -49.9 | 0.5 | -49.6 | 0.9 |
| S4TB-C | ND | ND | -53.2 | 1.2 | -52.9 | 0.5 | -53.1 | 0.2 |
| S4TB-S | ND | ND | -58 | ¿? | -58.3 | 0.4 | -55.4 | 0.8 |
| S5TB-N | ND | ND | -60º | ¿? | ND | ND | -61.4 | 2 |
| S5TB-C | ND | ND | -65º | ¿? | ND | ND | -65.1 | 0.5 |
| S5TB-S | ND | ND | ND | ¿? | ND | ND | ND | ND |
| SPR/SPH | ND | ND | -68.4 | ¿? | ND | ND | -68 | 1.2 |

**Table II: Average Reference Positions of Jupiter Belts 1907-2018. Zenographic Latitudes**

| BELTS NH | ß” | σ st | | BELTS SH | ß” | σ st |
|---|---|---|---|---|---|---|
| 1907-2018 | Average | Average | | 1907-2018 | Average | Average |
| NPR/NPH | +65,0 | 1,20 | | EB-Sn | -1,5 | 0,20 |
| N5TB-N | +59,9 | 0,20 | | EB-Sc | -3,0 | 0,25 |
| N5TB-C | +57,1 | 0,35 | | EB-Ss | -4,7 | 0,10 |
| N5TB-S | +52,3 | 1,00 | | SEB-Nn | -6,9 | 0,20 |
| N4TB-N | ND | ND | | SEB-Nc | -7,8 | 0,30 |
| N4TB-C | +50,9 | 0,20 | | SEB-Ns | -8,6 | 0,55 |
| N4TB-S | +48,2 | 0,50 | | SEB-N | -7,0 | 1,00 |
| N3TB-N | +47,0 | 0,68 | | SEB-Sn | -9,0 | 0,30 |
| N3TB-C | +44,5 | 0,80 | | SEB-Sc | -11,9 | 0,20 |
| N3TB-S | +41,8 | 0,67 | | SEB-Ss | -12,7 | 0,40 |
| N2TB-N | +39,0 | 0,60 | | SEB-Sn | -17,5 | 0,57 |
| N2TB-C | +37,6 | 0,80 | | SEB-Sc | -20,1 | 0,73 |
| N2TB-S | +35,6 | 0,70 | | SEB-Ss | -24,3 | 0,25 |
| NTB-Nn | +33,9 | 0,40 | | STB-N | -26,6 | 0,85 |
| NTB-Nc | +32,4 | 0,40 | | STB-C | -29,7 | 0,67 |
| NTB-Ns | +30,9 | 0,93 | | STB-S | -32,6 | 0,75 |
| NTB | +28,6 | 0,60 | | S2TB-N | -36,2 | 0,63 |
| NTB-Sn | +25,8 | 0,55 | | S2TB-C | -39,0 | 0,65 |
| NTB-Sc | +24,3 | 0,83 | | S2TB-S | -41,7 | 1,28 |
| NTB-Ss | +22,2 | 0,70 | | S3TB-N | -43,7 | 0,73 |
| NEB-N | +17,3 | 1,53 | | S3TB-C | -47,2 | 0,60 |
| NEB-C | +12,6 | 0,40 | | S3TB-S | -48,7 | 0,90 |
| NEB-S | +7,7 | 0,75 | | S4TB-C | -53,1 | 0,63 |
| EB-Nc | +1,5 | 0,10 | | S4TB-S | -57,2 | 0,60 |
| | | | | S5TB-N | -61,4 | 2,00 |
| | | | | S5TB-C | -65,1 | 0,50 |
| | | | | S5TB-S | ND | ND |
| | | | | SPR/SPH | -68,2 | 1,20 |

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2018: C.Foster (ALPO-Japan Jupiter Section web site)

2018: A.Vidal (ALPO-Japan Japan Jupiter Section web site)

ALPO_EEUU_Jupiter Section web site

RAS-Juno Europlanet Meeting 2018

Measures of latitudes & longitudes: WinJupos Software web site by Grischa Hahn (Dresden, GER)

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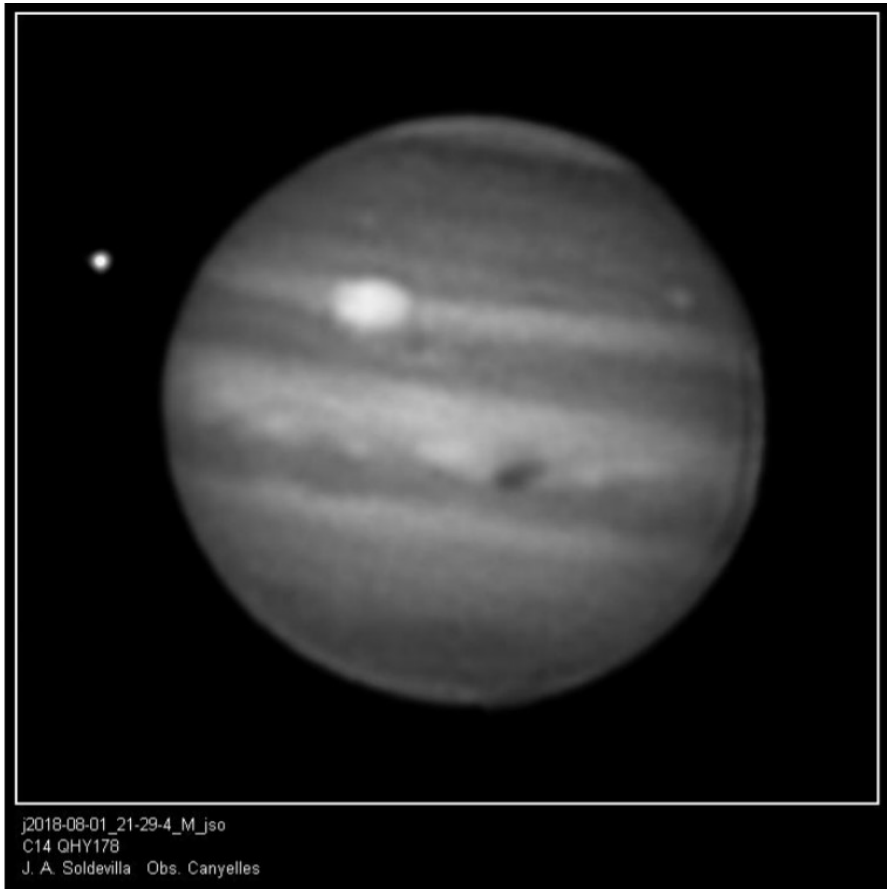


**Fig.7** JAS/ Baader CH-4/7nm filter

1.Jean-Luc Dauvergne 2.Glenn Orton 3.Peter Rosen 4.Manos Kardasis 5.Clyde Foster 6.Silvia Kowollik 7.Leigh Fletcher 8.Ricardo Hueso 9.Simon Kidd 10.Tirs Abril 11.Christopher Go 12.Joaquin Camarena 13. Agustin Sanchez-Lavega 14.Josep Soldevilla 15.Paulo Casquinha 16.John Rogers 17.Peter Edwards 18.John Sussenbach 19.Martin Lewis 20.Patrick Irwin 21.Candy Hansen 22.Ashwin Braude 23.Constantin Sprianu 24.Kuniaki Horikawa 25.Michel Jacquesson 26.Anthony Wesley 27.Sean Doran 28.Padma Yanamandra-Fisher 29.Peter Lawrence 30.Emil Kraaikamp 31.Matt Brealey 32.Gerald Eichstaedt 33.Marc Delcroix 34.Arrate Antuñano 35.Padraig Donnelly 36.Alexei Pace 37.Johan Warell 38.Christophe Pellier 39.Mike Foulkes 40.Manuel Scherf 41.Marco Vedovato 42.Miguel Araújo 43.Scott Bolton

**Fig.9** Pro-Am Jupiter observers in London, 2018 (J.A.Soldevilla is nº14)

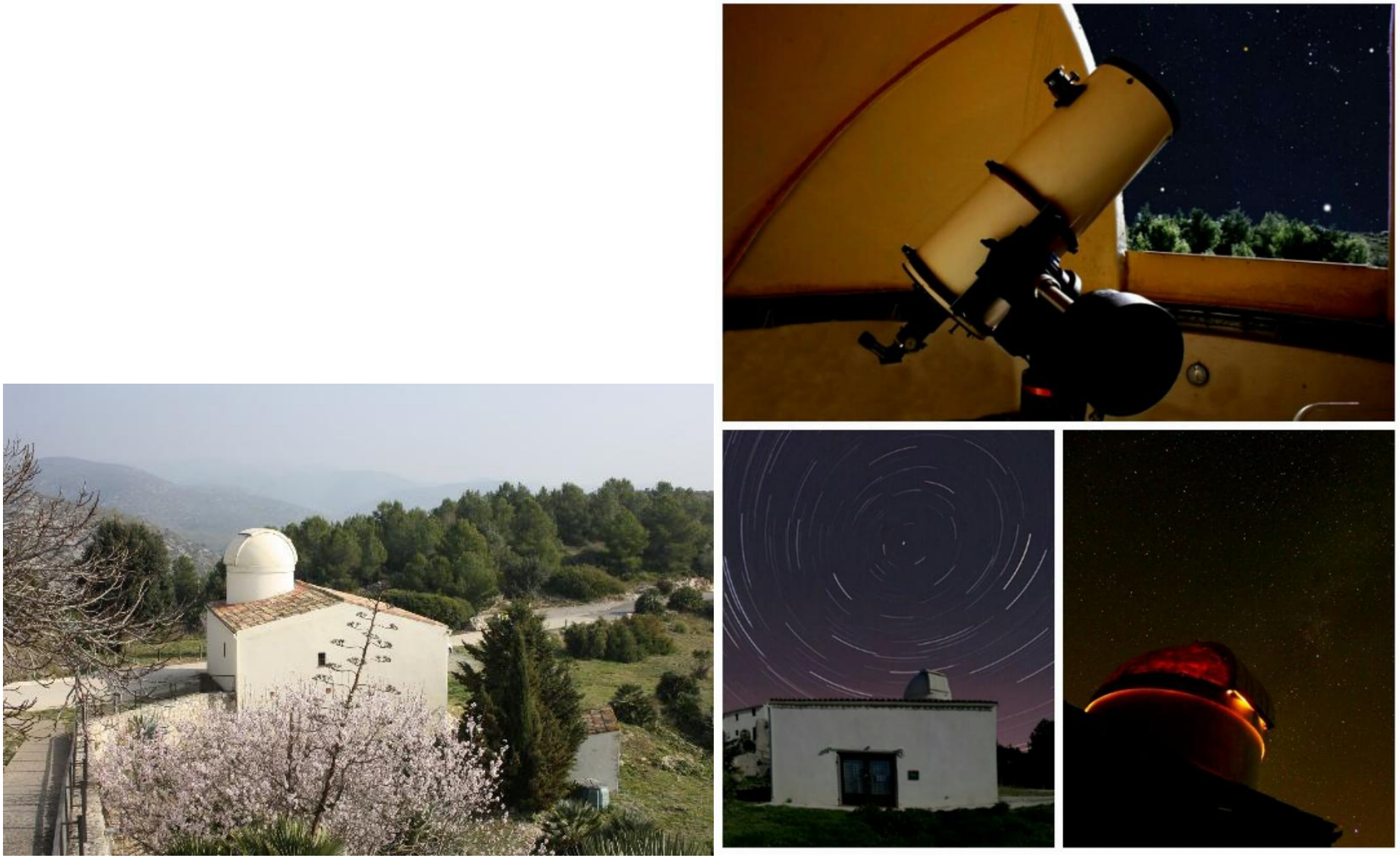

**Fig.10** The **Garraf Astronomical Observatory** (OAG) in the Garraf Natural Park  30km south of Barcelona. Is a private/public project for the development of Astronomy

Còsmik
astro
micro
outdoor
meteo
sci
AstronSCIENTIFIC
ASTRONOMY MADE EASY
Introducing
ROTARION
The first automatic eyepiece wheel.



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