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S106

Proceedings of the
Workshop and colloquium held at the CIAS (Meudon)
on October 14-18, 2015

**“Astrometry/photometry of Solar System objects after
Gaia”**



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Foreword

The modeling of the dynamics of the solar system needs astrometric observations made on a large interval of time to validate the scenarios of evolution of the system and to be able to provide ephemerides extrapolable in the next future. That is why observations are made regularly for most of the objects of the solar system.

The arrival of the Gaia reference star catalogue will allow us to make astrometric reductions of observations with an increased accuracy thanks to new positions of stars and a more accurate proper motion. The challenge consists in increasing the astrometric accuracy of the reduction process. More, we should think about our campaigns of observations: due to this increased accuracy, for which objects, ground based observations will be necessary, completing space probes data? Which telescopes and targets for next astrometric observations?

The workshop held in Meudon tried to answer these questions. Plans for the future have been exposed, results on former campaigns such as Phemu15 campaign, have been provided and amateur astronomers have been asked for continuing their participation to new observing campaigns of selected objects taking into account the new possibilities offered by the Gaia reference star catalogue.

We look now forward to the arrival of the Gaia data in order to define the future works and programs of observations astrometric reductions of solar system objects.

The organizing committee: J.E. Arlot, V. Lainey, V. Robert, E. Saquet.

Acknowledgements

We would like to thanks the CIAS for welcoming us in Meudon observatory and Nicole Letourneur for her kindness during our workshop.

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Table of contents

Programm of the workshop	9
Astrometric reduction of old observations before and after Gaia Vincent Robert	13
Digitization of astronomical plates and application Yan D., Xi X.J., Qiao R.C.....	17
The NAROO Project (New Astrometric Reduction of Old Observations) J.E. Arlot, V. Robert, V. Lainey.....	19
Astrometric reduction of the PHEMU observations: overcome obstacles to increase the accuracy Nikolay Emelianov.....	25
Short time span ephemeris for Pluto J.I.B. Camargo, J. Desmars, M. Assafin, R. Vieira-Martins, B. Sicardy, F. Braga-Ribas, G. Benedetti-Rossi, A. Dias-Oliveira, A.R. Gomes-Júnior, L. Beauvalet	31
Exploring the outer solar system with stellar occultations B. Sicardy	35
Gaia and the orbit determination of faint TNOs using Public Deep Surveys - Occultation Predictions Roberto Vieira Martins, Martin Banda, Ricardo Ogando, Julio Camargo.....	37
Astrometry and dynamics of SSOs with the Gaia satellite and the Gaia mission D. Hestroffer.....	39
Satellites and planets:which observations need theoreticians in dynamics? Alain Vienne	41
Improvement of ephemerides with Gaia catalogue Josselin Desmars	47
Determination of the Masses of Planetary Satellites from Their Mutual Gravitational Perturbations Nikolay Emelianov.....	53
Astrometric Observations from Space after Gaia – the Cassini Experience Nicholas J. Cooper, Carl D. Murray, V. Lainey, Michael W. Evans, R. Tajeddine, Kevin Beurle, Gareth Williams	55
The astrometric observation of planets through their natural satellites J.E. Arlot	61
What could be amateur astronomer contributions to post GAIA PRO-AM collaborations ? Thierry Midavaine.....	65

Imaging the natural planetary satellites J.E. Arlot	75
Discussion and conclusions.....	83
40 years of observation of the mutual phenomena J.E. Arlot	89
Observations of Galilean satellites close approach - astrometric results Roberto Vieira Martins, Bruno Morgado, Marcelo Assafin, Julio I.B. Camargo, Alex Dias de Oliveira	97
PHEMU 2015 - Brazilian campaign - preliminary results Roberto Vieira-Martins, Bruno Morgado, Marcelo Assafin, Alex Dias de Oliveira	99
Astrometry of the main satellites of Uranus J.I.B. Camargo, F.P. Magalhães, R. Vieira-Martins, M. Assafin, F. Braga-Ribas, A. Dias- Oliveira, G. Benedetti-Rossi, A.R. Gomes-Júnior, A.H. Andrei, D.N. da Silva Neto.....	101
The international astrometric network for astrodynamic studies of asteroids: asteroid mass determination and physical properties of PHAs A. Ivantsov, S. Eggl, D. Hestroffer, Z. Eker, M. Kaplan, O. Erece, V. Godunova, A. Simon, V. Vasylenko.....	103
Campaign of PHEMU 2014-2015 Participation of Astronomical Society of Tunisia (S.A.T) Sofien KAMOUN, Hanadi ETTROUDI.....	107
PHEMU 2015 observational campaign in the Astronomical Institute of the Romanian Academy A.Sonka1, M. Birlan, A. Nedelcu, M. Popescu	111
Visual observations of mutual eclipses of Galileian satellites with small telescopes under city lights Costantino Sigismondi	115
Proceedings of the International Workshop and Colloquium Astrometry/photometry of the solar system after the Gaia project and Phemu campaigns results, October 14-18, 2015, Paris France Cesar Valencia-Gallardo	119
High-resolution imaging of the mutual occultations and eclipses of Jupiter moons during the winter 2014/2015 John Sussenbach, Willem Kivits.....	123

Program of the workshop/colloquium “Astrometry/photometry of Solar System objects after Gaia” held in Meudon observatory on October 14-18, 2015

Below the list of the presentations made during the workshop (dedicated to answering questions on what to do after the arrival of Gaia data and during the colloquium on the project and observational campaigns

All the presentations are available on <ftp://ftp.imcce.fr/pub/colloquia/PHEMU-CIAS/presentations>

*Papers on the presentations are available below and at the Internet address:
on <ftp://ftp.imcce.fr/pub/colloquia/PHEMU-CIAS/proceedings>*

Note that papers in italic are not available (only the presentation).

Workshop, “answering questions” (October 14-16, 2015)

Session 1: REDUCTIONS

How to increase the astrometric accuracy using the Gaia reference catalogue?

-V. Robert

Astrometric reduction of old observations before and after Gaia

-X. Xi

Digitization and Position Measurement of Astronomical Plates of natural Satellites

-J.E. Arlot

The reduction of old observations: the NAROO project

-C. Le Poncin-Lafitte

Relativistic astrometry at the micro-arcsecond level

How to increase the accuracy of the mutual events to challenge direct astrometry with Gaia?

-N. Emelianov

Astrometric reduction of the PHEMU observations: overcome obstacles to increase the accuracy.

Session 2: OCCULTATIONS

How the star occultation observations will benefit from the Gaia project?

-P. Tanga

Gaia and the asteroid: the future of ground-based observations.

-J. Camargo

Short time span ephemeris for Pluto

-B. Sicardy

How the star occultation observations will benefit from the Gaia project

-R. Vieira-Martins

GAIA and the orbit determination of faint TNOs using Public Deep Surveys - occultation predictions

Session 3: OBSERVATIONS

What should be the astrometric observational program in the next ten years ? Which objects are still worth to be observed by ground based telescopes? How amateurs could help?

-D. Hestroffer

Astrometry and dynamics of SSOs with the Gaia satellite and the Gaia mission

-A. Vienne

Satellites and planets: which observations need theoreticians in dynamics?"

-J. Desmars

Improvement of ephemerides with the Gaia catalogue

-N. Emelianov

Determination of the Masses of Planetary Satellites from Their Mutual Gravitational Perturbations

Session 4: TELESCOPES

Which instruments for amateurs and professional after Gaia?

-F. Colas

The available ground-based telescopes for solar system objects observation.

-N. Cooper

Astrometric observations from space after Gaia

-V. Lainey

Observing bright satellites (Galileans): which techniques to be used?

-J.E. Arlot

Observing planets through their satellites

-W. Beisker

The detection limit of telescopes of the sub meter class with different CCD detector systems, with special respect to short exposure times.

-T. Midavaine

What could be Amateur astronomer contributions to Post GAIA Pro-Am collaboration? Review of the set up range of amateur equipments, how to update it? The problems encountered by the amateurs

-J.E. Arlot

Imaging the natural satellites: which techniques to be used

-Final discussion and conclusions of the workshop

Colloquium: programs of observations (October 17-18, 2015)

-J.E. Arlot

40 years of mutual events observations

-N. Emelianov

PHEMU-2015: review of the observations and preliminary astrometric results.

-R. Vieira-Martins

Observations of Galilean satellites close approach – astrometric results

-R. Vieira-Martins

Phemu 2015 – Brazilian campaign results

-J. Camargo

Astrometry of the main satellites of Uranus: 18 years of observations"

-A. Ivantsov

The international astrometric network for astrodynamical studies of asteroids: asteroid mass determination and physical properties of PHAs'

-H. Etttroudi

Participation to the Phemu15 campaign of the SAT

-A. Sonka, M. Popescu, D. A. Nedelcu, M. Birlan:

PHEMU 2015 - The Bucharest observational campaign"-Final discussion

-T. Midavaine

The amateur participation to Phemu15 campaign

-E. Bredner

How can we find new participants to our observations?

-E. Saquet

Review of the Phemu15 campaign: the photometric reduction

-C. Sigismondi

Visual observations of mutual eclipses of Galileian satellites with small telescopes under city lights

-C. Valencia Gallardo

Using the TimeBox for precise timing of astronomical phenomena using digital video devices.

-J. Sussenbach

High resolution imaging of the mutual events of the Galilean satellites during the 2015 Jupiter apparition

-W. Beisker

The detection limit of telescope: solutions and conclusions.

-B. Christophe and O. Dechambre

Observing Amalthea

-E. Saquet

Eclipses of the inner satellites of Jupiter

:

WHAT COULD BE AMATEUR ASTRONOMER CONTRIBUTIONS TO POST GAIA PRO-AM COLLABORATIONS ?

REVIEW OF THE SET UP RANGE OF AMATEUR EQUIPMENTS, HOW TO UPDATE IT ? PROBLEMS ENCOUNTERED BY THE AMATEURS

ASTROMETRY/PHOTOMETRY OF SOLAR SYSTEM OBJECTS AFTER THE GAIA PROJECT
WORKSHOP

MEUDON OBSERVATORY 14-16 OCT 2015

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KEYWORDS: amateur astronomer, pro-am collaboration, instrument setup

ABSTRACT:

Amateur astronomers contribute from the beginning to advanced research in astronomy. Solar System Objects (SSO) are still an intensive field of pro am collaborations. In the coming years of GAIA data release, what could be the new perspective of amateur activities? What is the range of amateur equipments? How could it be updated for this perspective? How could we support them to mitigate the problems and limitations they encountered?

1. INTRODUCTION

This is the proceeding attached to the presentation made at the workshop, thanks to refer to the PDF of the PPT I used during the lecture to get access to all the illustrations developed here. The paper gathered inputs from Club Eclipse members and from other association members we are networked with :

- Bernard Christophe
- Olivier Dechambre
- Christian Drillaud
- Thomas Flatres (SAR)
- Thierry Legault
- Michel Ory (MOSS)
- David Romeuf (Observatoire de Pommier)
- Cesar Valencia
- Jean-Marie Vugnon

2. AMATEUR ASTRONOMER TOPICS

Through a 2 years periodicity AFA (Association Francaise d'Astronomie) holds Les Rencontres du

Ciel et de l'Espace [1] in Paris. Several sessions are dedicated to the various fields of research from amateur observations. I used to consolidate these inputs and other publications from the astronomical community in a table [2]. to be able to deliver an up dated review of all topics. Appendix 1 at the end of this paper shows an extract of the file. The latest issue is currently available on the Club Eclipse Web Site [3]. Here is the table released just after the end of the workshop in Novembre 2015. Each line refers to a topic, with the related 5 amateur activity profiles :

- Discover Objects
- Follow Objects
- Contribute to event campaigns
- Perform Metrology
 - Astrometry
 - Photometry
 - Polarimetry
 - Spectroscopy
 - Vs time

➤ Exploit Data Base

A colour code allows identifying the activity for the beginner in blue, for the amateur equipped with a 8 inches class telescope in green, with a 20 inches or more telescope in yellow and the challenging topics requiring thousand hours or more in red.

We may prepare a new table issue to forecast the impact of the GAIA outputs.

Appendix 2 Shows the lines related to SSO with the focal points and organisations coordinating the respective topics.

End of 2014 a dedicated issue of Ciel et Espace reviewing the main topics in few pages was released [4].

3. AMATEUR MEASUREMENT LIMITS AND ACCURACIES

We may sum up the measurement limits and accuracies usually performed by amateurs.

3.1. Astrometry

Astrometric measurement on asteroids delivered to the MPC was checked once a year by Oleg Bykov from Pulkovo Observatory.

He gave me the feedback of O-C measurements I performed on the TJMS Buthiers [5] a 60cm F/3.4 with 9 μ m pitch camera. He gave me O-C 0,2 arcsec on asteroid around V16. Even with seeing induced angular resolution limited in the range of 1 to 3 arc sec, a nice SNR allows you to achieve an angular resolution 10 times sharper. In addition, a PSF larger than 2 pixels with a good SNR allows you to get an astrometric accuracy around 1/10 pixel. A mean value from several measurements reach O-C 0.1 to 0,08 arcsec from Oleg assessment. A key point is the catalogue and the software used to perform the astrometric reductions. On appendix 3 is a review of the star catalogues used in the past. Today latest UCAC catalogues are currently used in J2000. An open question was how long we will keep the J2000 frame ? For high resolution and accuracy astrometric reduction software performed the catalogue translation for the current epoch with the star velocity integration, refraction and aberration induced drift are then to be implemented to get the relative position of SSO for the current epoch. Then you perform the translation to the J2000 equinox.

3.2. Photometry

Photometric measurements could be done up to magnitude 19 with a 60cm class telescope rather easily in 60s long exposure. Therefore deeper detection are achievable in adding several exposures or better in performing longer exposure time if mount, tracking and background sky brightness meet the waited accuracies. The SNR will give the photometry accuracy. A 0,01 relative accuracy could be achieved thanks to an accurate methodology. A 0,001 routine accuracy is a real challenge. Turbulence, PSF random variation from exposure to exposure and on bright source background contamination could bring additional limitations on the effective SNR and magnitude measurement accuracy compare to the theoretical Poisson law limitation. Of course here I consider only relative magnitude measurement. Ref catalogue and spectral bands could bring from an observer to another one discrepancies in the measurements. Software improvement could brings improve capabilities in the future. Aperture photometry is currently used in algorithm image processing. We may wonder if fitted PSF filtering could be used to reach such improvement.

3.3. Timing events

Video cameras with DCF77 was first used to get 10ms accuracy in recording events like Phemu and asteroidal star occultations. Thanks to the use of PPS form GPS and drift-scan mode in CCD camera, 1ms accuracy has been achieved 10 years ago thanks to pioneered work made with Audine setup and eventaude device. Today 10 μ s accuracy could be achieved from the GPS PPS with device like the time box. In fact 100 μ s is currently achievable due to software limitation. Does sharper time accuracy is a real need in astronomy ? Whatever, we showed during WETO workshops, an effective qualification of complete acquisition chain is still mandatory to control any timing bias induced by latencies and rms jitter. In addition PPS, NMEA code and software writing time stamping may induce a # 1,0000s time shift !

3.4. GAIA catalogues

Therefore it could be interesting to foresee the benefits in amateur measurements bring by the GAIA catalogues. It is necessary to prepare a 10GB and 100GB version of the catalogues to allow a nomad use. It will be necessary to update these shorten catalogue may be once a year. Therefore GAIA1 catalogue scheduled for summer 2016 with 100000 stars will be the first issue of such shorten ref catalogue [6].

An open question is do we keep data reduction in the J2000 frame. Up to when J2000 will be used. Do we foresee to move to J2025 or J2050 in the future? From the discussion it is agreed that J2000 epoch could be used till for several years. The accurate used algorithm does not induced bias in astrometric reductions. We may dream of a time ref source in the sky like a Pulsar or a beacon on a geostationary satellite to share an optical time ref in the sky to test and control acquisition setups.

4. GAIA OUTPUT

The 1 billion objects GAIA catalogue will issue unusual objects from cinematic, photometry variation or spectral signatures, ambiguities from multiple object signature fusion. These may feed an uncommon object list to be checked. This list could be 1 million objects long if we assume 1/1000 of the GAIA catalogue list is uncommon or ambiguous. Amateur astronomer task force could be helpful to solve these candidates and select them for deeper analysis for professional means. A web site to manage this activity gathering GAIA, amateur and professional in a collaborative team.

5. Updating amateur setup

During the 15 last years Asian industrial manufacturing of telescopes reduced the market prices. Affordable refracting telescope up to 150mm diameter Achromat (700€) or event Apochromat (1700€) are available with F/8 or even F/5 numerical aperture. For larger aperture,

Newton telescope 200mm class (700€) up to 300mm diameter (2500€) on equatorial mounts are available. For larger aperture Ritchey Chretien telescopes are entering in mass production from 300mm aperture (3400€) up to 500mm (14000€). F/2 F/3 class setup was also introduced on the market using the primary focus of Newton, Schmidt Cassegrain or Ritchey Chretien integrating a camera with a correcting lens instead of the secondary mirror. For larger telescopes more and more amateur societies are proposing 60cm and above class telescopes for amateur missions or ProAm collaborations. In France I found today 27 telescopes.

The most productive telescope amateur set-up for astrometric measurements and SSO discoveries is the Claudine Rinner and Michel Ory MOSS Observatory [7].

6. CONCLUSIONS

To conclude I would like to share several ideas or actions arising from this presentation, the workshop and from discussions during the workshop for amateur involvement.

- Amateur silver halide picture archives on SSO are meaningful for new astrometric reduction. Even grandfather pictures from beginning of the XXth century could be gathered for data reduction.
- Light diffusion level in the optic and sky background during occultation are variable during the events on bright sources (Phemu) inducing photometric bias
- Softwares [8, 9, 10, 11] for photometric reduction of recordings (occultation, eclipse, variable, transit,...) could be improved. Variable PSF induce the noise level of the data. We are far from photon noise limitation.
- Jupiter satellite photometry vs rotation and phase angle has to be measured. Referenced measurements show discrepancies. B, G, R, I, Methane bands measurements are wished.
- On asteroid astrometry priorities on potentially hazardous objects (PHA).
- The successful recordings of Phemu events on small Jupiter satellites (Amalthe and Thebe) with 60cm class telescope motivate the preparation of dedicated campaign on these satellites for the next Phemu period.
- For the above campaign a network of 60cm telescope with a preferred optomechanical set up (planetary coronagraph) with a planet occulter, mask to reduce optical diffusion and

filters are to be proposed on each telescope.

- Does GAIA catalog may allow the prediction ground track of bright star occultations from earth grazing asteroids ?
- New generation of low noise CMOS arrays embedded in cooled cameras brings new capability and sensitivity allowing the reduction of exposure time. Small pixel pitch allows the use of short focal length and high aperture optics to reach more quickly the sky background induced noise.
- Low cost microbolometers may open new infrared windows to amateur : see picture 6
- GPS based devices [12, 13] allow 1ms time stamping accuracies on the recordings.

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3. Midavaine Th. Club ECLIPSE web site : http://astrosurf.com/club_eclipse
4. Guide Pratique de la Science Participative en Astronomie. Ciel et Espace Hors Série 2014 AFA editor.
5. TJMS Planete Sciences
6. GAIA1 first catalogue to be published summer 2016 : 100000 stars up to 1mas and 14mas/yr accy
7. <http://www.moss-observatory.org/index.php>
8. PRISM 10
9. Limovie
10. IRIS
11. MUNIWIN
12. TIMEBOX
13. EVENTAUDE

Appendix 1

Objets Unités	Découverte Mag min	Suivi	Evenement	Météorologie	Astrométrie arcsec	Photométrie Précision	Polarisation Taux de Pol	Spectroscopie Résolution	Rés Temp seconde	Exploitation sur Internet	Point Focal France
Météorites		Fripou									Brigitte Zanda
Météores	4	Vigie Ciel	Fragmentatio	Orbite, Impact	60				1		Karl Antier
Essaims d'étoiles filantes	1	Orbite	Sursaut	ZHR Radian	240				60		J. Vaubillon
Cratères d'impact terrestre										Google Earth	David Baratoux
Aurores Boréales											
Night Glow											
Sprite											
Rayons Cosmiques											
Lune			TLP	Occultation	Rasante		0.1	10	0.1	Moon zoo	
Impacts sur la Lune			flash								Sylvain Bouley Uranoscope
Lumière Cendrée								10			Luc Arnold
Lumière Zodiacale											
Planètes		Météorologie	Tempête, Occultation					100	1		SAF commission des planètes
Venus		UV ou PIR									Christophe Pellier
Mars										planet four	
Jupiter			Impact								Marc Delcroix
Saturne											
Uranus, Neptune			Tempête								Marc Delcroix
Satellites de Planètes	21		Occultation	Phemu	0.04	0.1			1		Jean-Eudes Arlot, Bruno Sicard
Astéroïdes (orbites)	19	Position	Occultation		0.2	0.1			0.1	http://www.asteroids.org	Jerome Berthier
Astéroïdes (objets)		CdR	Occultation			0.05		10	0.1	Asteroids@home	Benoit Carry, Eric Frappa
Satellites d'astéroïdes	CdR ou Occu	CdR	Occultation			0.01			0.1		Raoul Behrend
Géocroiseurs AAA	19			Orbite, Impact				10	0.1	orbit@home	Mirel Birlan
Objets Trans Neptuniens	20		Occultation	Myosotis	0.2	0.2		10	10		Bruno Sicard
Objets de la bande de Kuiper								10			Francoise Roque
Comètes	14		Sursaut, Fragmentation		0.2	0.2		100	1	Soho	Commission Comètes SAF
Comète 67P Tchouri			CdR								
Soleil Taches		Nbre Wolf					0.05	1000	0.1	Soho	Didier Favre
Soleil Protubérances			Eruption, Eclipe				0.05	1000	0.1	Solar stormwatch	Franck Vessière
Soleil Couronne			Eclipe Totale								
Etoiles										DASCH	
Etoiles à record				Mouvement p	0.1	0.1		10	10000		CDS
Jumelles du Soleil	9										
Etoiles Doubles	11				0.1	0.1		10	100000		David Valls Gabaud
Binaires Spectroscopiques								1000			Daniel Bonneau
Binaires à éclipses	10	CdL				0.1	0.1	1000			Laurent Corp
Etoiles Variables	10	CdL				0.1		100		aavso.org/vsx	Dominique Proust
Céphéides											
RR Lyrae	14	GRRS				0.1		10000	8000		Jean-Francois Le Borgne
Delta Scuti						0.1					
Etoiles Be, Eruptives	7		Sursaut			0.1		1000	10000		Valérie Desnoux
Etoiles OB actives											Christian Buil
Etoiles Cataclismiques											Etienne Morelle
Etoiles Symbiotiques											Francois Teyssier
Nouvelles classes variables						0.001			100		Denis Gilet
Pulsars	10					0.1			0.01	einstein@home	Fabrice Mottez
Trous Noirs Galactiques											
Disques Stellaires										diskdetective.org	
Planètes Extra Solaire		Vitesse radia	Transit			0.01		10000	10	planetshunters.org	Alexandre Santerne
Super-Terres										Kepler	Jean-Philippe Beaulieu
Satellites de Planètes Extra Solaire						0.01			10		Jean Schneider, David Kipping
Vie extraterrestre										seti@home	
Novae de la Voie Lactée	10					0.05			10000		
Super Novae Voie Lactée	0										
Remanents de SN					1		0.1	1000	100000		Agnès Acker
Nébuleuses Planétaires	16			étoile centrale			0.1	600		Digital Sky Survey	Agnès Acker, pascal le du
Nébuleuse de Wolf-Rayet											Agnès Acker
Nébuleuses								1000			
Bulles cosmiques										Milky way project	
Amas d'étoiles et asterisme	9					0.01		10		Milky way project	Jose Peña Institut d'Astronomi
Amas Globulaires											
Voie Lactée										MilkyWay@Home	
Galaxies naines											
Galaxie d'Andromède	Novae									PHAT	
Novae galaxies voisines											
Amas d'étoiles galaxies voisines										http://www.projectstardate.org/	
Galaxies	green peas	Classification								Galaxy zoo	
Galaxies à noyaux actifs											
Micro Quasars											Katherine Blundell
Quasars	15		Sursaut			0.1		10	10000		Jean Schneider
Supernovae	14 - 21		Discontinuité			0.1		10	10000	http://tarot.obs-hp	Emmanuel Conseil
Gamma Ray Burst	18	contrepartie	optique			0.1			10000		CESR, Alain Klotz
Trous Noirs Super-Massifs											
Amas de Galaxies											
Filaments extragalactiques											David Valls Gabaud
Lentilles Gravitationnelles										space_warps	
Autres Objets											
Matière Noire											David Martinez-Delgado Max F
Energie noire											
Cosmologie					0.1			10		cosmology@home	SAF Commission Cosmologie
Code Couleurs Sujets Coll Amateurs-Pro		Facile		Exigeant		Difficile		Challenge		www.zooniverse.org	
V2 5 Novembre 2015 Thierry Midavaine Club Eclipse										boinc.berkeley.edu	
Pour tous compléments et corrections adresser un mail à		thierrymidavaine@sfr.fr								scistarter.com	Thierry Midavaine
Publications de référence	Hors-Série 22 Ciel et Espace		Guide Pratique de la Science Participative en Astronomie	Collectif							
										http://arxiv.org/pdf/1305.3647v1.pdf/	
										www.afanet.fr/sciences-participatives-afa.pdf/	

Table 1: of the Amateur Astronomer topics

Appendix 2

Objets Unites	Découverte Mag min	Suivi	Evenement	Métrologie	Astrométrie arcsec	Photométrie	Polarisation	Spectroscop	Rés Temp	Exploitation sur Internet	Point Focal France	Organisation site web	e mail	Conférence
Météorites		Fipon				Precision	Taux de Pol	P Résolution	seconde			astro-proam.com		
Météorites	4	Vigie Ciel	Fragmentatio	Orbite, Impact	60					1	Brigitte Zanda	Fipon		
Essaims d'étoiles filantes	1	Orbite	Sursaut	ZHR Radian	240					60	Karl Antier	REFORME	reformameteor.net	International Meteor Confer
Cratères d'impact terrestre											J. Vauclair	IMO	www.imo.net	International Meteor Confer
Aurores Boréales											David Baratoux		www.spaceweather.com	
Night Glow														
Sprite														
Rayons Cosmiques														
Lune			TLP	Occultation	Rasante			0.1		10	Sylvain Bouley Uranoscope	ALPO, IOTA	users.aber.ac.uk/tip/tip.htm	
Impacts sur la Lune			Flash								Luc Arnold	IMCCE	http://uranscope.free.fr	
Lumière Cendrée														
Lumière Zodiacale														
Planètes		Météorologie	Temple	Occultation						100	SAF commission des planètes	ALPO	www.astrosurf.com/planetessail/	European Planetary Scienc
Venus		UV ou PIR									Christophe Pelier	SAF		
Mars														
Jupiter			Impact								Marc Delcroix	SAF	delcroix.marc@free.fr	
Saturne														
Uranus, Neptune			Temple											
Satellites de Planètes	21		Occultation	Phemu	0.04	0.1				1	Marc Delcroix	SAF	delcroix.marc@free.fr	
Astéroïdes (orbites)	19	Position	Occultation		0.2	0.1					Jean-Eudes Ariot, Bruno Sicar	IMCCE	www.imcce.fr/phenom9	
Astéroïdes (objets)		CdR	Occultation			0.05					Jerome Berthier	MPC	www.minorplanetcenter.net/iau/	
Satellites d'astéroïdes		CdR ou Occd	Occultation			0.01					Benoit Carry, Eric Frappa	EAON, IOTA	mpc@cfa.harvard.edu	ESOP
Géocroiseurs AAA	19										Raoul Behrend	CdR-CdL	http://obswww.unige.ch/~behrend/page_cou.html	
Objets Trans Neptuniens	20			Orbite, Impact							Mirel Biran	EURONEAR	http://www.minorplanetcenter.org/iauNEO/TheNEOPage.html	
Objets de la bande de Kuiper			Occultation	Myosotis	0.2	0.2				10	Bruno Sicard	MPC		
Comètes											Françoise Roque	CBAT	www.cfa.harvard.edu/iau/mpc.html	
Comète 67P Tchouri	14		Sursaut, Fragmentation		0.2	0.2				100	Commission Comètes SAF	GEFOS	http://solarclimbase.free.fr	liste astrosoleil
Soleil Taches		Nbre Wolf	CDR					0.05		1000	Didier Favre	Observateurs	www.climso.fr	
Soleil Protuberances			Eruption, Eclipse					0.05		1000	Franck Vessiere		http://rosetta.jpl.nasa.gov/rosetta-ground-based-campaign	
Soleil Couronne			Eclipse Totale											

Table 2: Lines related to Solar System Object

Appendix 3

Catalogue	Année	MagLim	Nbre d'étoiles	Précision	Taille du fichier	Remarques
Hipparque	-200		700	30'		
Ptolémée	150		1022	10'		
Tycho Brahe				2'		
Hevelius	1690			1'		
Flamsteed	1725			15as		
La Caille				4as		
John Bird Jesse Ramsden				1as		
D. Gill J. Kapteys			450 000	1as		
Bessel	1818		36		36 étoiles fondamentales	
Plaque photo				0,13as		
Henry Draper						
SAO	ref 1950		250 000		Précision 1,5 as à ne plus utiliser	
FK4	1963		1 535		Précision 0,1 as	
FK5	1986		1 535		Nouvelle équinoxe, constante précession, mvt propre	
FK5 extended	1988		3 000		Précision 0,08 as	
FK6	2000		4150		Wielen R. et al Part I 1999, Part III 2000	
BSC		7	9 096		Les étoiles les plus brillantes	
Hipparcos	1993	13	117 955		Précision 0,001 as	
Hipparcos 2	2007				van Leeuwen F.	
Tycho 1			118 218		Précision 0,03 as	
Tycho 2	2000		2 539 913		Hog E.	
GSC		13 et 16	15millions	216MO	précision 1,5 as ancien, inclus dans Prism6	
GSC ACT				291MO	Plus recent, inclus dans Prism7	
GSC 2.3						
AC2000						
AGK2						
USNO SA1		20 reg espacées	55millions	1CD		
USNO SA2					idem SA1 en plus précis	
USNO A1		20 B R	550millions	10CD		
USNO A2		20 B R			idem A1 en plus précis préférables aux GSC	
USNO-B1.0		21	1045913669	80GO	accessible en ligne préférable aux USNO-AX	
UCAC 1					petit domaine du ciel Sud, Obsolète	
UCAC 2		de 7,5 à 16 R	48millions		-90° +50°, magnitude entre B et R, obsolète	
UCAC 3	2009	mag 8 à 16 V		8GO+ (2DVD)	1% de bug, obsolète	
UCAC 4	2013	mag 8 à 16.3 v-r	113 780 093	8GO (2DVD)	20mas, photométrie 2MASS, APASS en B, V, g, r, i	
Nomad v1				environ 100GO	des anomalies sur les magnitudes	
PPM			380 000		précision 0,3 as	
PPMX	2008		18 088 919		Roser S.	
PPMXL	2010	mag 20 V	910 468 710	4DVD 37GB zip	combine USNO-B1.0 & 2MASS précision 0.3as	
/Vizier						
CCMC 14						
CMC15						
2MASS	1999	infrarouge				
DENIS		infrarouge				
URAT		18	20mas		USNO Robotic Astrometric Telescope	
URAT1	2015	3-18.5 R	228millions	10 – 30 mas 18GB	VizieR Hemisphere Nord à -15° 2013.5 5mas/yr CDS	
URAT2	2016					
GAIA 1	2016		100000		1-2 mas de précision 14–134mas/yr	
GAIA 2	2018		10 ⁹ objets		Précision 7 μas	
GAIA	2020		10 ⁹ objets			

Table 3 : Astrometric catalogue review

Carte de France des T50 et plus

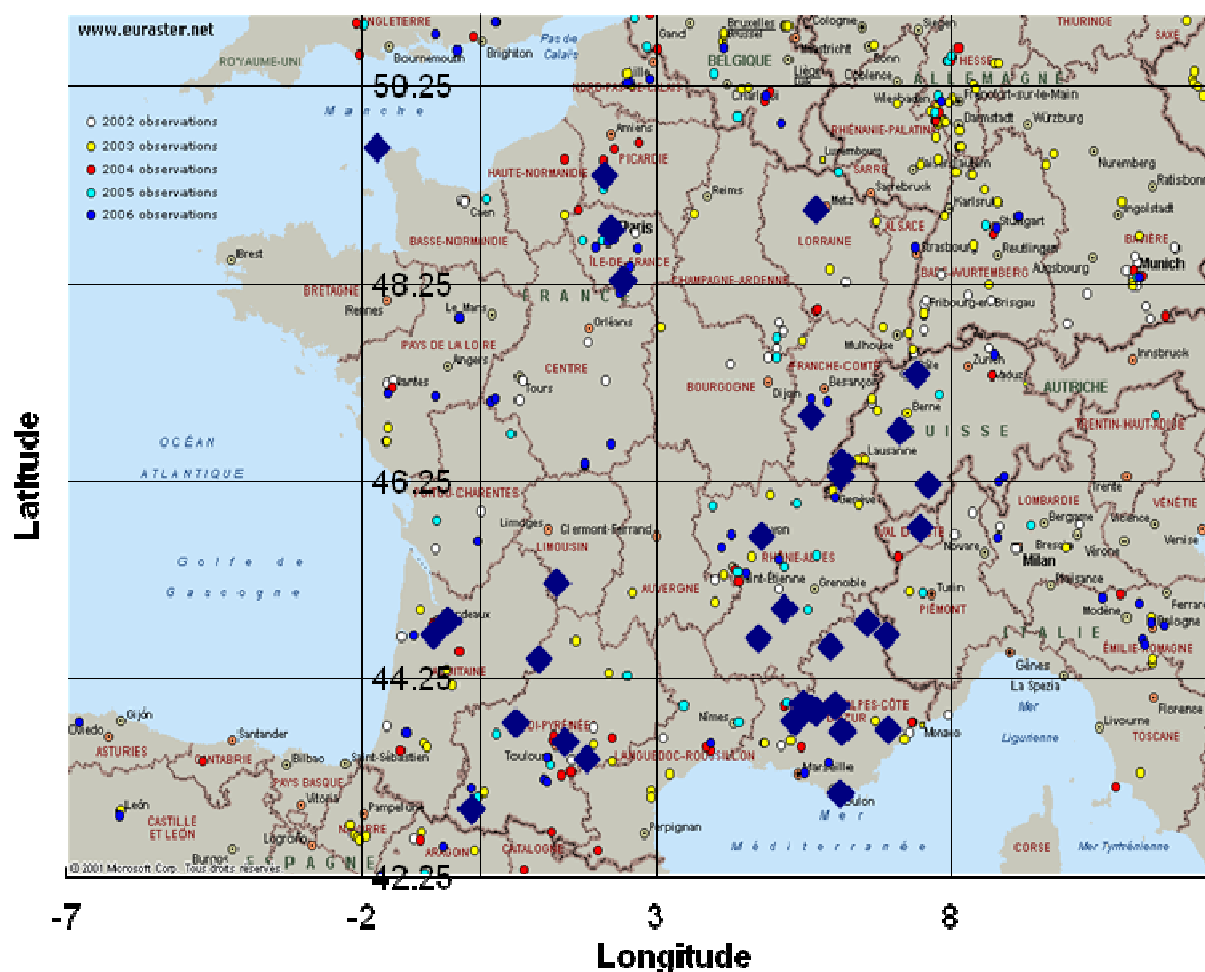


Table 4 : Above 50cm class telescopes in France (Blue Losange) on the Eric Frappa map on occultation observer network

Obs Astro Val d' Meudon	Centre de Recherche astronomique de Lyon	OHAM	Les Makes	OBP Baronn Saint-Caprai	Bauduen	OHP	OCA Calern	CLE1HM	Mars
	SAL	SAP Toulouse	AGORA	e-scop sarl	OAB Observatoire Astronomique de Bauduen	Astronomer C2PU	SAT		
oui	non	513	181 B10	en cours			910		
	non	non	55°410	E5,5°	6°17E				4°20'07"
			-21.198	44.4N	43°73N				45°00'25"
1600			1000	820					1080m
	Cassegrain	Cassegrain	Ritchey Chretien						Ritchey Chretien
0.8	0.6	0.83	0.82	0.82	0.94	1.52	1	0.66	0.6
5			6.4	3.28	Paracorr				5E-10
					40				
			f/3	6.56	Barlow X2				
				1	Nasmith f/D20				
oui			1.8						
HIS39			ST 11000M						Apogee
KAF1001E			KAI 11002M						
1024 x 1024			4008x2672						
			9						
			657x495 7.4µm						
			C14		Lunette de 120mm			Dobson406	LX200 12"
			1						
téléphone	demande								
	non			16					
indisponible fin 2005	vendredi soir			Véhicule	Voiture				
				14					
250				50/pers					
2000/10j			700 pour 4 - 5 personnes		250				
				200					
www.oavda.it	http://www-obs.ui	www.astrosurf.co	www.saptoulouse.net/	www.obs-bp.com	http://www.observatoire-astronomique-de-bauduen.com	www.clubastro			
Saint Barthélemy	dominique.proust@obs-lyon.fr	sal@astrosurf.co	sal@saptoulouse.net	obs.astronomique@wanadoo.fr	olivier.planchon29@orange.fr				
3911020	Loc. Lignan	69561	69230	18 rue Georges Bizet	Quartier les vallons				
Nus	Saint Genis Lava	69561	69230	97421	83630				0
3 90166E+11	Saint Genis Lava	674422629	674422629	Les Makes, la Rivière	Bauduen				Mars
		Bernard Reynaud	Bernard Reynaud	262378683	06 76 05 96 36				
		bernard.reynaud@free.fr							

Table 5B : 60cm class telescopes in France or closed to France

Observatoires 60cm et sup Unité	T60 OMP	Château Renard J.M.S Buthiers	Cotes de Meuse Sirene	Plateau du Mou Luviver	Col de la Lebe	Belesta	La ferme des ét OHP St Michel	OHP St Michel	FXBagnoux
Associations	AT60	Astroqueyras	Sirene	Centre d'Astronomie	Club astro nature	Adagio	A Ciel Ouvert	CNRS	
Station UAI n°	non	615	216	oui	oui	non	oui	non	non
Long	00°09'32"	6°54'24"E	05°29'13"E	5° 43' 17" E	1°39' O	00°48'E	00°48'E	E 5°43'54 "	
Lat	42°56'12"	44°41'52"	44°00'00"	43° 54' 22" N	49°37' N	43°54	43°54	N 43°52'36"	
Alt	2861m	2931	92	1100	560	180	250	180 600 m	601 m
Instrument	Newton	Cassegrain	Coudé	Newton	Newton	Newton	Newton		Newton
Diamètre Pupille	0.6	0.62	0.83	0.635	0.583	0.6	0.82	0.62	0.8
Focale	2.13	9	3	13	2.2	2.83	3.1	2.4	12
Correcteur de champ	oui	non		non					
Champ utilisable	arcmin								
Focale combinaison 2	2.01 Wynne 3pou	2	4.8			4.5	13.9		
Focale combinaison 3	7.5	9.6				9.6			
GoTo	non	oui	oui	oui	oui	NON	oui	non	
seeing moyen	2	1.5	3	3					
Pose max (dérivé<seeing)	600	60	5 visuel uniquement	60					
Caméra CCD	STL6303E	U16M	Apogee	Platinum	MX916, synonym Audine	ST8e	ST6	ANDOR	AP47
CCD	KAF6303E	KAF 16803	AP47-10 ?	KAF402ME	KAF 400			Marconi ccd aminci 42-40	Marconi 47-10
Pixels	3072x2048	4096x4096	4008x2672	768x512	512 x 512	768x512	378x242	2048x2048 13.5 pixels champs 7	1024x1024
pas pixel	9	9	9						
Autres caméras	Ethernaude 1603 HISIS22	Ethernaude 1600							
Cam Video	Watec 120N	Mitron	DMK						
Spectro	Lihres III	Musicos	non	oui (Barège)	non				
Autre instrument	Lunette de 120	RC500	coro H 100mm	T406 sur ZX10 et ST7, webcam	webcam			LORIS en cours de réalisation	HISIS44
Accès par Internet									
Missionnaires									
Demande de mission	écrit 3mois avant écrit en février	oui	oui	oui	oui	oui	oui	Tél/mail/courrier	
Comité des programmes	oui	oui	non	non	non	non	oui	oui	
Membre	club et individuel	club ou indiv	non	non	non	non	non	individuels et clubs	
Autonome si Agrément	oui	oui ou chaperon / oui	non	non	non	non	non	oui	
Nbre de personnes max	4	6	15	8 1 à 40	10	9	12	15	20
Accueil mineurs	non	non	oui	oui	oui	oui	oui	oui	
durée min de mission	6 7 en été, 1 en hiv	1	1	1	1	1	1	1	
Coûts									
accès	téléphonique	piste, ski l'hivers	RER	véhicule	véhicule				
Age minimum	18	18	0						
adhesion	25	25 50/Club							
Instrument/nuir	15/pers	compris	125	150 70/pers maxi	142 5	150 27/pers	152 150 / nuit (animal	40	500CHF
Instrument/semaine	€	compris	775	nous consulter	non	non	nous consulter		
Hébergement	€/pers/nu	22 compris	12	30 tous types d'hébe Pension C. 30,50 non, gîtes à 10 mn	non	non	possible sur plac	Oui, supplément	Centre d'Astronomie
Forfait une semaine	€/pers/semaine	175		non	non		de 10 à 44 /p		
Repas	€	12.5 cuisine sur place	12	#NOM?	11.5 non		de 12 à 19 / repa	Oui, supplément	
Nombre de nuit/an	100	100	100						
Pour les Contacter									
Site web		www.planete-sci.fr	www.observatoire.1836.fr	www.astroqueyras.com	www.astroqueyras.com	www.astroqueyras.com	www.astroqueyras.com	www.astroqueyras.com	www.astroqueyras.com
e-mail		castels.martine@wanadoo.fr	observatoire.1836@sirene.com	contact@centre-ludiver.com	contact@centre-ludiver.com	contact@centre-ludiver.com	contact@centre-ludiver.com	contact@centre-ludiver.com	contact@centre-ludiver.com
Adresse		Marie de Saint-V Base Régionale c 8 place de Verdun ZL 12 - D 34	Centre d'Astronomie 1700 rue de la Lit Canv						
code postal	65000	5350	77760	4870	50460	1260	31450		3961
ville	Bagnères de Bigl Saint-Véran	Buthiers	Viéville-sous-les	Labastide-Beauv Fleurance	Charancin	Labastide-Beauv Fleurance	561818866		Saint Luc
telephone		671068923	169027610	492766969	233781380	479876731	562060976		41274755808
Thierry Midavaine 19/06/10									
thierymidavaine@sfr.fr									
Contact pour les mises à jour									

Table 5A : 60cm class telescopes in France or closed to France



Picture 6 : Moon total eclipse recorded in the 3 – 5 μm IR thermal band