

## RAPAS, PRO-AM NETWORK FOR THE SCIENTIFIC ALERTS

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**Abstract.** Several projects on the ground and in space benefit from the help of amateur observers in coordination with professionals. Among them the Gaia mission is probably one of the most emblematic examples. In addition to the periodical data releases, the Gaia mission also delivers, almost daily, alerts for the detection of transient events: unreferenceed solar system objects, unknown stellar or extragalactic sources with strong photometric variations. Moreover, alerts are multiplying following the deployment of numerous robotic telescopes on the ground (ZTF, ASSAS-SN, ATLAS, CRTS, etc...) which also require a classification. Through a Pro-Am collaboration supported by Paris Observatory, we propose to strengthen and coordinate the response to these alerts from the ground which allows the rapid validation of the detections and their monitoring on the medium term. This collaboration will concern in particular the study and the deployment of photometric methods with a homogeneous and standard system of filters in the amateur community. This collaboration, planned for a 3 year period, will also be able to react to other future alerts, in particular those of the LSST (Vera Rubin Tel.), of the Gravitational Waves or of the next French-Chinese satellite SVOM. The Observatoire de Paris in the framework of the 2022 call of the multi-year incentive action Pro-Am, selected in March 2022 our proposal. We present the work that we intend to initiate this year, with in particular a call to amateurs, for a first campaign to evaluate the achievable limiting magnitudes and a workshop scheduled at the Paris Observatory to engage amateurs in this network of response to alerts.

Keywords: transients, network, pro-am, Gaia

### 1 Introduction

Observational programs generating astronomical alerts are increasing. The sources of these alerts can be of very different natures, from the detection of new objects of the Solar System to Supernovae or Gamma Ray Bursts, passing by Novae or eruptive stars for example. Future alert generation programs are also in perspective for the next years. Finding the optical counterparts of these alerts, locating them precisely and classifying their nature is a task where amateurs with their networked instruments can efficiently contribute to the discovery of transient phenomenon. The follow-up of the phenomenon can then be carried out by the amateurs or mobilize large professional instruments which is the opportunity of Pro-Am collaborations.

### 2 Surveys and transients

Many observational programs are operating nowadays and they generally need the help of networks of observers on alert to cover the evolution of newly detected transient objects. We can for example cite the ATLAS survey (Tonry et al. 2018), MASTER network (Lipunov et al. 2010), ASAS-SN, DLT40 (Tartaglia et al. 2018) and Black Gem at La Silla. A special mention must be done for large surveys with large field of view, such as PTF-ZTF (Law et al. 2009) at Palomar observatory, Pan-STARRS at Hawaii (Magnier et al. 2020), the space mission Gaia posted at the Lagrange point L2 (Gaia Collaboration; Prusti et al. 2016) and soon Vera Rubin Telescope/LSST (LSST corp. 2009) in Chile. In practice, all of these surveys provide or will provide the data necessary to make follow-up observations.

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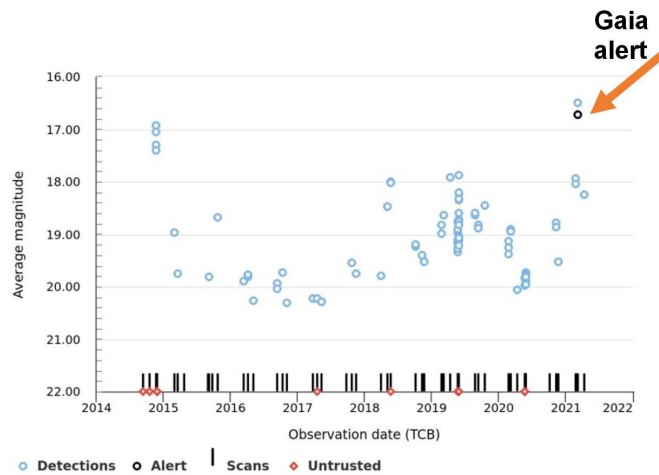
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For example, the Gaia consortium, apart from periodic data release rare dates, publishes data on a quasi daily basis. It triggers scientific alerts as soon as a transient event or object is detected (Hodgkin et al. 2021). These observations on alert are necessary because Gaia's orientation is forced by a scanning law and it cannot monitor its own detections, which otherwise would result in sparse data preventing analysis or even identification, as shown in Fig. 1.



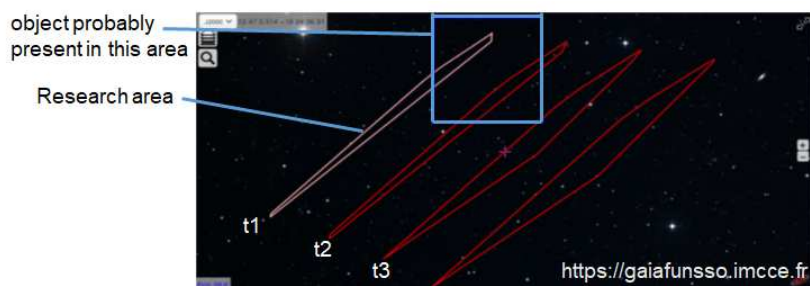
**Fig. 1.** Example of lightcurve issued from sparse Gaia data: the triggering of alert will allow to monitor this outburst (credit: [gsaweb.ast.cam.ac.uk/alerts/](http://gsaweb.ast.cam.ac.uk/alerts/))

Photometry and spectroscopy are required for the follow up of different astrophysical events (such alerts can be found at <http://gsaweb.ast.cam.ac.uk/alerts/alertsindex>). Astrometry from the ground is also needed for the validation and monitoring of new Solar System Objects detected. The Gaia-FUN-SSO activity, dedicated to these astrometric alerts, and the results obtained are described in Carry et al. (2021) (such alerts can be found at <https://gaiafunss0.imcce.fr/>). A lot of these detections are for the magnitude range 20-21 but several of brighter magnitude can be detected with the field of view given by amateur telescopes in the range of 20-50 cm diameter with digital camera. In this case, the orbital prediction being based on a too short orbital arc, the observer has to retrieve from the ground a newly detected object in a predicted search area of the sky as shown in Fig. 2.

### 3 A new pro-am activity

To find the optical counterparts of the alerts, to locate them precisely, when necessary, and to classify their nature constitutes a task where the amateurs with their instruments in network can contribute to the discovery of the transient phenomenon. Then the follow-up of the phenomenon can be carried out by the amateurs or mobilize large professional instruments. In this framework, with the support of the Paris Observatory scientific council, we are organizing a new professional-amateur activity, planned for a 3 year period, called RAPAS (Reseau Amateur Professionnel pour les Alertes Scientifiques).

The RAPAS project aims to build such a network and to encourage amateurs to participate to the follow up of such scientific alerts with efficiency. Spectroscopy and astrometry are concerned but photometry is probably mostly practiced by amateurs, that is why in a first step photometry is our main concern. Usually, different photometric systems are used by amateurs: Johnson Cousins, Sloan, Bessel, RGB, which makes not easy the link between the measures. There is a high interest to use homogeneous photometric system to make easier the



**Fig. 2.** Example of sky map diffused on alert for 3 dates to retrieve a newly detected Solar System Object (blue square : 12 arcmin).

comparisons and the analysis of observations. We propose a filter system as wide as the BP-RP range used by Gaia, to improve sensitivity over narrower filters like the Sloan ones, but with well defined edges on the blue and red extremities. The Gaia space mission constitutes on the one hand a first source of generation of alerts, and on the other hand delivers a wide catalog until magnitude 20 - 21 in a photometric broad band system. In the third data release (DR3) delivered in June 2022, we have 1.806 billion sources with G (Gaia band) photometry, 1.542 billion and 1.555 billion sources in Gaia Blue band (BP) and in Gaia Red Band (RP). Furthermore cross references toward the most current systems are proposed.

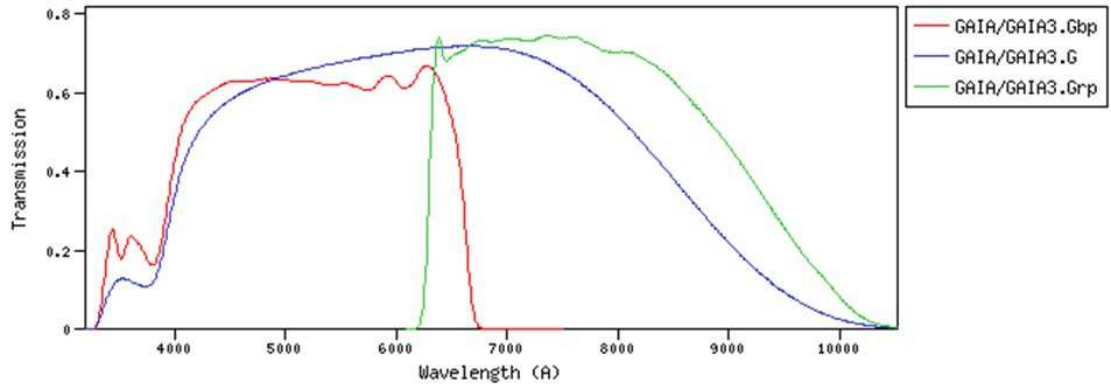
Therefore we propose to equip a first circle of amateurs with filters compatible with the Gaia photometric system. A set of filters is therefore under construction this year and will be distributed (under certain conditions) to a selected circle of amateurs joining this network. We have then chosen bandwidths similar to the Gaia , G, BP and RP bandwidths as shown in Fig. 3.

In addition, thanks to the help of the Jules Janssen Conference Center (Paris Observatory - PSL university), we organize a kick-off meeting in October 2022, held in Paris Observatory in order to bring together amateurs and professionals, to discuss among several topics, the triggering of alerts, the nature of the astrophysical sources, the observational methods to apply, the filters to use and the data collection (programme access: <https://rapas.imcce.fr>).

In order to contribute to the RAPAS activity, amateurs equipped with an instrument of at least 200 mm diameter can register on the GEMINI web page at <https://proam-gemini.fr/rapas/> and declare there some characteristics of their instrumentation.

#### 4 Summary

We are initiating a new professional-amateur collaboration called RAPAS (Réseau Amateurs Professionnels pour les Alertes Scientifiques). This project mainly aims to organize a network to contribute to responses to warning observations related to the various terrestrial and space surveys. The idea is that amateur telescopes, because they are numerous and geographically dispersed, can be very useful for acquiring data after a transient event detected by surveys. Spectroscopy and astrometry are concerned but, initially, photometry which is mainly practiced by amateurs, is our first concern. Several actions are planned, in particular the construction of filters



**Fig. 3.** Filter system as wide as the BP-RP range used by Gaia. This model is used to design the filter bandwidth which will be released, taking into account the atmospheric bands.

similar to the Gaia bandwidths G, BP, RP and their availability to amateurs for homogeneity and compatibility between the results. In October 2022 we organize also a workshop at Paris Observatory to diffuse information upon different astronomical systems triggering alerts, to promote methods which will improve the observational data, and generally to bring together amateurs and professionals.

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