Report on the recently concluded visit in connection with Follow-up organization and associated classification of Gaia transients

Purpose of the visit:

The proposed meeting was to devise concrete steps towards follow-up organization for Gaia transients and their subsequent classification. This report is best read with the background description included when the proposal was made (appended for easy reference).

Description of the work carried out:

I attended two meetings during the visit: The plenary meeting in Brussels (21-23 June) and the [Gaia alerts verification and follow-up](#) meeting in Cambridge (Jun 29-30, Jul 1). During these meetings there were useful discussions with various other attendees related to availability of telescopes for follow-up. In Cambridge I also gave two talks. One was on the Catalina Realtime Transient Survey (CRTS - http://crts.caltech.edu/) where we currently detect transients in realtime, publish them in different ways for people to get information about them, and also carry out follow-up observations with a few telescopes which gets fed back into the system. This portfolio per object allows us to characterize and classify each object better. The second talk was related to the follow-up organization and the different factors that are involved e.g. Aperture, Location, Instruments, Seeing, Available, Interests etc. on the one hand, scheduling issues related to scientific, sociological and even political aspects on the other. All the talks at the meeting are archived on the wiki: http://www.ast.cam.ac.uk/ioa/wikis/gsawgwiki/index.php/Workshop2011:agenda

Given the limited resources, prioritization of the resources is crucial in order to make optimal decisions on follow-up. The question 'What shall we follow today?' can be looked at in three ways all of which are important: '**What** shall we follow today?', 'What shall **we** follow today?', and 'What shall we follow **today**?'.

After the discussion we started putting together a list of telescopes which can contribute to Gaia follow-up, along with all necessary parameters associated with them e.g.. size, field of view, typical number of cloudless nights, CCD size, limiting magnitude, time available, observing mode, contact person etc. A full list and the entries can be found at the following URL. The list will be updated as more information becomes available.
https://spreadsheets.google.com/spreadsheet/ccc?key=0AgPX6wFm4RGMdHhHYlpOdng4c2lSTFJxazZoSkFxclE&hl=en_GB&authkey=CJHAnaEK#gid=0

The other crucial aspect is the feedback of information once new data are taken by follow-up telescopes. In order for these data to be useful, they should be processed and fed back into the parent system. It is planned to use the Skyalert software from Caltech and used for CRTS for Gaia transients. It can receive the original stream, disseminate the information about transient events as well as run various annotators on archival data and run characterization/classification programs

besides receiving the feedback information from telescopes. Roy Williams (Caltech) gave a detailed talk on various aspects of SkyAlert (http://www.skyalert.org). Different telescopes have different amount of preparedness (fully robotic, semi-automated, completely manual etc.), and they all can be accommodated. The follow-up processing on the other hand, will need at least an automated pipeline which has the following steps (for imaging, and an analogous set for spectroscopy): (1) bias subtraction, (2) flat fielding, (3) WCS incorporation, (4) calibration. Steps 1 and 2 are typically done at each telescope, 3 is easy to incorporate using software like astrometry.net. It is in step 4 that uniformity is needed and is often not available as an observatory-wide resource. It was decided that a central calibration pipeline will be set up at IoA, Cambridge. Observatories will do the steps up to and including WCS incorporation and hand over the images to the central repository where calibration and the remaining steps of incorporation in skyalert portfolios will happen.

Initial testing of the follow-up and the reduction pipeline will be done using CRTS transients which have a magnitude range and frequency similar to Gaia (CRTS transients are selected to have high threshold values keeping the total number per night tractable).

Summary:
The visit, in combination with the workshop, resulted in the following concrete steps towards follow-up organization and classification of transients with Gaia: (1) Installing skyalert, (2) identifying telescopes for follow-up of Gaia transients, (3) initiation of a uniform calibration pipeline for follow-up data. There were discussions related to various annotators required for characterization and classification which can be incorporated in to skyalert. These will be done after some test transients from CRTS are observed with the follow-up facilities. These are the first steps towards an end-to-end system for follow-up and classification of Gaia transients.

Other comments:
The nature of this work was somewhat different in that a system is being set-up. The work was related to the set-up, but the real work begins only now – actual observations, pipeline, and streamlining of scheduling of observations as well as classification based on the follow-up. Further work will be carried out with the host institute as well as the various observatories involved. These should result into several publications.

Background description from the proposal:
Since transients fade in a relatively short time interval it is important to obtain follow-up observations for the rarer ones for best scientific returns. The steps to (1) choose best transients, (2) determine possible follow-up telescopes and (3) further classify using the additional data points as well as archival data is being studied for the Catalina Realtime Transient Survey (CRTS).

This proposal is to request a short term visit for Ashish Mahabal who is in charge of the follow-up for CRTS which publishes its transients in real-time. Follow-up is obtained in a semi-automated format from Palomar, New Mexico and CTIO. Spectroscopy and some imaging is also obtained from the IUCAA-Girawali Observatory in India, and some data will be obtained from telescopes in South Africa in the near future. Many programs are being developed for realtime classification of transients based on raw data, follow-up data and archival data using Virtual Observatory standards and the VOEvent protocol as the underlying layer. In order to get ready for Gaia transient follow-up and classification we propose to start getting some follow-up for CRTS transients form various small European telescopes. By the time Gaia is operational, the entire machinery will be fully functional and the transition to Gaia follow-up will be straightforward. Parallelly we will also be setting up VOEvent network and classification routines. Ashish has attended two Gaia meetings previously and is conversant with the Gaia processing requirements and other detail.

We propose a short visit coinciding with the Gaia Science Alerts and Follow-up Workshop (28 June -1 July, Cambridge) so that various Gaia personnel working on the project will be available for discussion. Additionally, to get folks from other projects and telescopes on board and maximizing collaboration and interaction hours, we suggest that the visit include the plenary GREAT meeting (21-23 June, Brussels). The suggested period is from June 19 to July 3.

Expected Outcome: The proposed visit will allow taking concrete steps towards follow-up organization and transient classification for Gaia.

More details can be provided if needed.
Ashish Mahabal <aam@astro.caltech.edu>

Host:
Lukasz Wyrzykowski <wyrzykow@ast.cam.ac.uk>
Institute of Astronomy, Cambridge