INDO SWISS JOINT RESEARCH PROGRAMME (ISJRP)

JOINT UTILISATION OF ADVANCED FACILITIES

EXCHANGE GRANT REPORT

Grant No.: RF 25

Part 1 - General Information

<table>
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<th>Project Title:</th>
<th>Gravitationally lensed quasars: measuring the Hubble Constant</th>
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<td>Keywords:</td>
<td>Cosmology; Gravitational lensing; Hubble Constant; Image processing</td>
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<td>Start date:</td>
<td>September 15, 2010</td>
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<td>Duration:</td>
<td>2 months</td>
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Part 2 - Exchange Participant(s) Details

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Part 3 - Scientific & Technical Information

3.1 Purpose of visit

(Briefly describe the purpose and goals of this exchange.)

The Indian Institute of Astrophysics (IIA) in Bangalore is actively involved in the COSMOGRAIL (COSmological MOntoring of GRAvItational Lenses) collaboration, led by the Laboratory of astrophysics (cosmology) at LASTRO, EPFL. This collaboration aims at determining the Hubble constant (i.e., the age of the Universe) to an accuracy < 2% by monitoring a large sample of gravitationally lensed quasars coupled with detailed theoretical modeling of the lensing galaxies. The Himalayan Chandra Telescope (HCT) operated by IIA, Bangalore, has been monitoring five objects since 2007. The purpose of this particular two-month visit was to learn and use the specific codes developed by LASTRO - EPFL to analyse the data acquired with the HCT.

3.2 Short description of work carried out during the visit

(Please describe the technologies acquired and the experiments/activities performed during the course of the exchange.)

From 2007 to July 2010, a total of 561 epochs (with each epoch consisting of a minimum of three image frames) of observations were collected for five doubly imaged gravitationally lensed quasars using the HCT, operated by IIA. During this visit to EPFL, all the image frames acquired until July 2010 were pre-processed using the image reduction pipeline (suited to the reduction of HCT data) developed at EPFL. These pre-processed image frames were then spatially deconvolved using the MCS (Magain, Courbin & Sohy 1998, ApJ, 494, 472) deconvolution algorithm, further developed significantly by EPFL. After applying this sophisticated MCS code, photometric light-curves of all the five objects monitored from HCT were generated. The time delay between the lensed quasar images were then estimated using the dispersion technique implemented in Python. In summary, during this visit to EPFL, Rathna Kumar has obtained the time delay between the lensed images in all the five quasars which are being monitored from HCT since 2007. These time delays are one of the important inputs to measure the Hubble constant.

This visit also has enabled Rathna Kumar to master the special techniques of pre-processing and deconvolution which is specifically suited to photometric flux variations of lensed quasars. These algorithms and all corresponding softwares are now installed in IIA, Bangalore and used in the framework of the PhD thesis of Rathna Kumar.

3.3 Outcomes

(Please describe the main results obtained during the course of the exchange.)

This collaborative two-month exchange has led to the following results: (i) measurement of the flux variations of the lensed quasar images for all the five lensed quasars using the data acquired with the
HCT between 2007 – 2010 and (ii) estimate of the time delays between the flux variations of the quasar images in all the five lens systems.

3.4 Future collaboration with host institution

(Please provide information on future collaboration opportunities and follow-up activities.)

Observations of these lensed systems need to be continued further to decrease the errors on the time delay estimates obtained so far. We plan to continue using HCT facility available with the Indian Institute of Astrophysics, Bangalore. Also, the time delays obtained using the dispersion technique (during this two month stay at EPFL) need to be confirmed using new statistical techniques, which we plan to develop in the coming six month, in close collaboration IIA in Bangalore and LASTRO at EPFL. Also, to convert the time delay estimates obtained from observations, theoretical modeling of the lens system will be undertaken in the future, along with EPFL. We also plan to expand this collaboration between IIA and LASTRO at EPFL beyond COSMOGRAIL as well.

3.5 Various comments

(E.g., what worked well, what didn’t work well, suggestions and improvement ideas, ...) 

The visit was absolutely essential in improving interaction with the collaborators in LASTRO, learn new techniques and exchange of ideas between IIA and LASTRO. The present trip to EPFL has strengthened the collaboration between our two institutes.

3.6 Projected publications/articles resulting or to result from the exchange

(if applicable)

We aim to publish the results of one of the five objects during the year 2011. The results of the remaining objects will be published in separate papers in the subsequent years.