

Report for 2010 from the Bordeaux IVS Analysis Center

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Abstract

This report summarizes the activities of the Bordeaux IVS Analysis Center during the year 2010. The work was focused on (i) regular analysis of the IVS-R1 and IVS-R4 sessions with the GINS software package; (ii) systematic VLBI imaging of the RDV sessions and calculation of the corresponding source structure index and compactness values; (iii) testing of a pipeline to model-fit VLBI structures in an automatic way; and (iv) continuation of our VLBI observational program to identify optically-bright radio sources suitable for the link with the future Gaia frame. Also of importance is the implementation of the *IVS Live* Web site which allows one to monitor IVS sessions in real time and to view source images.

1. General Information

The “Laboratoire d’Astrophysique de Bordeaux” (LAB), formerly Bordeaux Observatory, is located in Floirac, near Bordeaux, in the southwest of France. It is funded by the University of Bordeaux and the CNRS (“Centre National de la Recherche Scientifique”). VLBI activities are primarily developed within the M2A team (“Métrologie de l’espace, Astrodynamique, Astrophysique”).

The contribution of the Bordeaux group to the IVS has been mostly concerned with the maintenance, extension, and improvement of the International Celestial Reference Frame (ICRF). This includes regular imaging of the ICRF sources and evaluation of their astrometric suitability, as well as developing specific VLBI observing programs for enhancing the celestial reference frame.

In addition, the group is in charge of the VLBI component in the multi-technique GINS software package [1] as part of a collaborative effort within the French “Groupe de Recherches de Géodésie Spatiale” (GRGS) to combine VLBI and space geodetic data (SLR, GPS, DORIS) at the observation level. This effort also involves space geodesy groups in Toulouse, Grasse, and Paris.

2. Description of Analysis Center

The Bordeaux IVS group routinely analyzes the weekly IVS-R1 and IVS-R4 sessions with the GINS software package. During the past year, weekly normal equations for all such sessions in 2009 and 2010 (with 6-hour EOP resolution) have been produced and integrated in the multi-technique solutions derived by the GRGS within the framework of the “Combination at the Observation Level” (COL) Working Group. Additional work was dedicated to implementing operational procedures for automating the data processing with GINS and for assisting in evaluating the results.

The group is also focused on imaging the ICRF sources on a regular basis by systematic analysis of the data from the RDV sessions which are conducted six times a year. This analysis is carried out with the AIPS and DIFMAP software packages. The aim of such regular imaging is to characterize the astrometric suitability of the sources based on the so-called “structure index”, and to compare source structural evolution and positional instabilities. Such studies are essential for identifying sources of high astrometric quality as for the ICRF2 [2] or the future Gaia link.

3. Scientific Staff

During the past year, several changes occurred with IVS staff. The most significant event is that Géraldine Bourda obtained a permanent position at the LAB, starting on 1 September 2010; this position comprises research, teaching duties, and IVS service activity. With two researchers and two engineers on permanent positions, the IVS group can now build on solid ground. Also Ming Zhang's CNRS post-doctoral fellowship ended on 30 September 2010; he then went back to China and obtained a permanent position at Urumqi Astronomical Observatory. Yet another change is Alain Baudry's retirement on 1 September 2010; now with a part-time ESO contract to accomplish ALMA duties, he still spends time at the LAB and keeps contact with VLBI and IVS. In all, six individuals contributed to IVS analysis and research activities during 2010. A description of what each person worked on, along with the time spent on these activities, is given below.

- Patrick Charlot (20%): overall responsibility for Analysis Center work and data processing. His research interests include the ICRF densification, extension, and link to the Gaia frame, studies of source structure effects in astrometric VLBI data, and astrophysical interpretation.
- Antoine Bellanger (80%): engineer with background in statistics and computer science. His tasks are to process VLBI data with GINS and to develop procedures and analysis tools to automate such processing. He is also the Web master for the M2A group.
- Géraldine Bourda (50%): now with a permanent position at the LAB. She is tasked with developing the VLBI part of GINS and is responsible for the analysis results derived from GINS. She also leads a VLBI observational program for linking the ICRF and the future Gaia frame.
- Arnaud Collioud (100%): engineer with background in astronomy and interferometry. His tasks are to process the RDV sessions with AIPS and DIFMAP to image the sources, to maintain the Bordeaux VLBI Image Database (BVID), and to develop VLBI2010 simulations.
- Ming Zhang (50%): post-doc fellow funded by the CNRS (until 30 September 2010). His work has been targeted towards finding automatic ways to model-fit VLBI structures and extract physical information with the aim of studying the evolution of the sources from the BVID.
- Alain Baudry (10%): radioastronomy expert with specific interest in radio source imaging and astrometric VLBI. Retired since 1 September 2010.

4. Analysis and Research Activities during 2010

As noted above, a major activity of the Bordeaux group consists in imaging the sources observed during the RDV sessions on a systematic basis. During 2010, two such sessions were processed (RDV76 and RDV78), resulting in 370 VLBI images at either X or S band for 156 different sources. The imaging work load has been shared between the USNO and Bordeaux groups since 2007 (starting with RDV61): the USNO group processes the odd-numbered RDV sessions while the Bordeaux group processes the even-numbered ones. The VLBI images are used in a second stage to derive structure correction maps and visibility maps along with values for structure indices and source compactness (see [3, 4] for a definition of these quantities) in order to assess astrometric source quality. All such information is made available through the Bordeaux VLBI Image Database (BVID)¹. At present, the BVID comprises a total of 2108 VLBI images (with links to an additional

¹The BVID may be accessed at <http://www.obs.u-bordeaux1.fr/BVID>

7124 VLBI images from the Radio Reference Frame Image Database of the USNO at either S, X, K, or Q band) along with 9232 structure correction maps and as many visibility maps.

Plans to take advantage of this wealth of VLBI images for astrophysics have also been initiated. For this purpose, a pipeline that automatically fits Gaussian components to the observed VLBI structures and subsequently estimates jet proper motions and flux density variability has been developed [5]. Comparison with results obtained manually for a few sources shows excellent agreement in the case of structures with strong and well-separated VLBI components, whereas results sometimes disagree for structures that comprise weak and/or blended VLBI components. A comparison for a large data set (50 to 100 sources) is now underway to assess the potential use of this pipeline to study source structural variability in a systematic way from the BVID data.

The other major activity in the group is an observational program to identify and characterize appropriate radio sources to align the ICRF and the future Gaia optical frame. To this end, dedicated VLBI observations of a sample of 398 optically-bright radio sources have been undertaken [6]. From this sample, an initial 105 sources have already been imaged, half of which show the required properties in terms of astrometric suitability [7]. During the past year, a total of 106 hours of observing time was allocated to image an additional 215 sources. These observations were carried out in March and November 2010 with a 15-station network combining the European VLBI Network and the Very Long Baseline Array. Observations of the remaining sources are planned for March 2011 to complete the imaging work. Next will come dedicated astrometric observations of the most compact sources identified though such imaging to accurately measure their positions.

5. Dissemination and Outreach

As reported in [5], the Bordeaux group set up a dynamic Web site displaying VLBI images of the observed radio sources in real time for the particular IVS session dedicated to the International Year of Astronomy 2009 (IYA2009) which took place on 18 November 2009. Following this event – which drew quite a lot of interest – the IVS Directing Board suggested that the IYA09 Web site be extended in order to make it run for every IVS session. The work was carried out during 2010, and a final product, *IVS Live*, was presented for approval to the IVS Directing Board in October 2010. The *IVS Live* Web site may be reached from the IVS home page or directly at the following address:

<http://ivslive.obs.u-bordeaux1.fr/>

IVS Live is meant both as an outreach and a scientific tool. The main reason for its existence is to monitor IVS sessions in real time and to view source images (Fig. 1). But it can also be used to navigate through IVS sessions and to search for specific information about sources and stations. It will be regularly updated and extended in order to increase its value to the IVS community. The most recent enhancement is a display of the projected source direction on the terrestrial map.

6. Outlook

Our plans for the coming year are focused on moving towards operational analysis of the IVS-R1 and IVS-R4 sessions with the GINS software package. We will also continue imaging the RDV sessions in cooperation with USNO as well as evaluating the source astrometric suitability based on structure index and source compactness indicators. In addition, we expect to develop astrophysical interpretation of the BVID data by using the pipeline that we have developed to

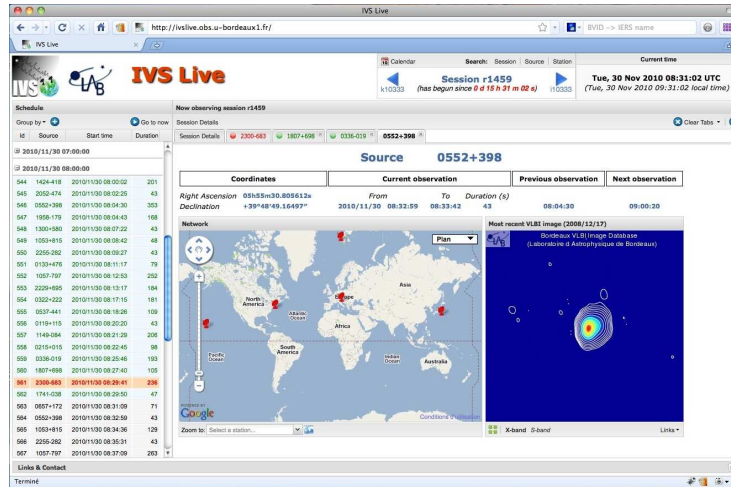


Figure 1. A snapshot of the *IVS Live* Web site while observing the source 0552+398 in the course of the IVS session R1459 on 30 November 2010. See the December 2010 IVS newsletter for details on the functionalities.

model-fit VLBI structures in an automatic way. Regarding the Gaia link, our goal is to complete the VLBI imaging of the 398 optically-bright radio sources selected for this purpose, to assess their astrometric suitability, and to engage in astrometric observations on the most compact of these sources. Simulations of the VLBI2010 system's imaging capabilities will also be started again with focus on the assessment of the accuracy of the structural corrections derived from such images.

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