Report for 2011 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 2011. The work 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) imaging of the sources observed during the 2009 International Year of Astronomy IVS observing session; 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 enhancement of the *IVS Live* Web site which now comprises all IVS sessions back to 2003, allowing one to search past observations for session-specific information (e.g. sources or stations).

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 the 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 2011 (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. The CONT08 session was also reanalyzed in the same way. Specific studies were conducted to compare different analysis strategies for the EOP determination and to test the impact on the analysis of new stations and of stations displaced by earthquakes. Finally, a pipeline was developed to characterize the observing sessions in a graphical form.

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, for example for the ICRF2 [2] or the future Gaia link.

3. Scientific Staff

During the past year, there were no changes in the IVS staff. In all, five individuals contributed to IVS analysis and research activities during 2011. 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%): astronomer in charge of developing the VLBI part of GINS and 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 image the sources in the RDV sessions using AIPS and DIFMAP, to develop the Bordeaux VLBI Image Database and *IVS Live* tool, and to conduct VLBI2010 simulations.
- Alain Baudry (10%): radioastronomy expert with specific interest in radio source imaging and astrometric VLBI. Professor Emeritus and with a part-time ESO contract.

4. Analysis and Research Activities during 2011

As noted above, a major activity of the Bordeaux group consists of imaging the sources observed during the RDV sessions on a systematic basis. During 2011, three such sessions were processed (RDV80, RDV82, and RDV84), resulting in 532 VLBI images at either X or S band for 213 different sources. The imaging work load has been shared with USNO 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 3181 VLBI images for 1075 different sources (with links to an additional 7851 VLBI images from the Radio Reference Frame Image Database of USNO at either S, X, K, or Q band) along with 11,032 structure correction maps and as many visibility maps.

Another major piece of work that took place during the past year was the analysis of the International Year of Astronomy 2009 (IYA2009) specific IVS session [5] with the aim of imaging the sources. This session, which was conducted on 18 November 2009, was remarkable in that it used a 32-station network and observed 243 of the 295 ICRF2 defining sources. Analysis of such a large data set required modifications of the AIPS software package so that it can handle that many stations. In all, 232 sources were successfully imaged, a sample of which is shown in Figure 1. Most of the images show very compact structures, as expected for defining sources. This property will be assessed in a more quantitative way in the future by calculating source structure indices.

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

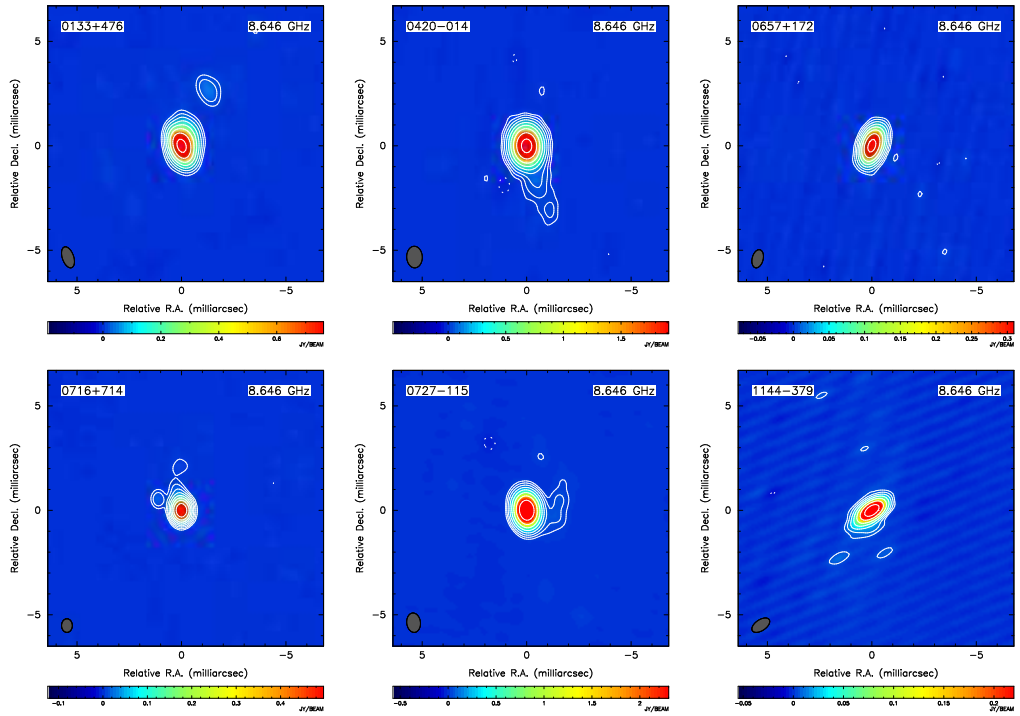

Figure 1. VLBI images at X band for six ICRF2 defining sources with declination ranging from −40° to +70° (0133+476, 0420−014, 0657+172, 0716+714, 0727−115, and 1144−379). These sources were observed during the IYA2009 session organized by IVS on 18 November 2009 with a 32-station VLBI network.

On the observational side, the group leads a project to identify and characterize appropriate radio sources to align the ICRF and the future Gaia optical frame. To this end, dedicated VLBI imaging observations of a sample of 395 optically-bright radio sources have been conducted, beginning in 2008 [6, 7]. The last set of sources (75 sources) was observed in March 2011 during a 38-hour long experiment combining 15 stations from the European VLBI Network (EVN) and the Very Long Baseline Array (VLBA) (as for previous experiments). All data sets have been analyzed, the results of which will be presented at the upcoming IVS General Meeting. In all, 250 sources have been successfully imaged, and roughly half of them show the required properties in terms of astrometric suitability. Additionally, we are examining the ICRF2 to identify those sources that also meet the criteria for the alignment. Preliminary results indicate that about 200 of them are in this case [8]. Hence, we anticipate that ultimately there should be more than 300 sources to align the two frames, a similar number to the number of defining sources in the ICRF2.

5. Dissemination and Outreach

During the past year, the *IVS Live* Web site [9] was updated on a regular basis and enhanced. In particular, all IVS sessions back to 2003 have been added to the database. With this addition, there is now a total of 4,834 IVS sessions available. These sessions involved 63 stations and observed 1,633 sources. As described in [9], *IVS Live* allows one to monitor IVS sessions in real time and view

source images but also to search for specific information about sources and stations in past IVS sessions. Monitoring of the connections showed that there were about 1,500 visits from around the world during 2011, with at least half of them coming from different individuals. Locally, the Web site was presented to the public during an open day session at the Observatory on 15 May 2011.

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. Additionally, we are considering a specific analysis for estimating time series of radio source positions. Imaging of the RDV sessions and evaluation of the astrometric suitability of the sources will continue along the same lines. On the observational side, dedicated astrometric observations of the ∼125 sources that are deemed to be suitable for the Gaia link (see Section 4) will be considered. A proposal will be submitted to the EVN and the VLBA to this end. Furthermore, we plan to make a complete assessment of all 3,400 ICRF2 sources for the same purpose. The list of targets for the Gaia link will then be finalized, and we will ask IVS to strengthen observations of these sources. Finally, we will also prepare plans for monitoring such sources during the Gaia mission, which will be launched the year after (in 2013).

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