Second RVS meeting

Asiago, Linta Park Hotel, 7-9 February 2002

RVS–CoCo–003

25 February 2002

U.Munari, D.Katz

This short note is aimed to summarize the content of the second RVS meeting that was held in Asiago (Italy), on 7-9 February 2002, by providing the list of partecipants, the final meeting program, and the abstract of the talks given at the meeting. The meeting photo (by S.Ansari) can be viewed at `http://ulisse.pd.astro.it/RVS.jpg`

Partecipants

Salim	Ansari
Frederic	Arenou
Giampaolo	Bertelli
Corrado	Boeche
Giuseppe	Bono
Federico	Boschi
Fiorella	Castelli
Francoise	Crifo
Mark	Cropper
Andreja	Gomboc
Amina	Helmi
Urtzi	Jauregi
Carme	Jordi
David	Katz
Paola	Marrese
Ulisse	Munari
Andrej	Prsa
Frederic	Royer
Alessandro	Siviero
Rosanna	Sordo
Frederic	Thevenin
Rosaria	Tantalo
Lina	Tomasella
Catherine	Turon
Yves	Viala
Tomaz	Zwitter

Program

February 7

13:00 —— Lunch

15:30 *Report on the last GST meeting*
D.Katz

16:00 *Design of the instrument*
D.Katz, F. Sayede, D. Horville

16:30 *Field-rotation/distortion and filter issues for GAIA-RVS*
M.Cropper

17:00 *Crowding in the RVS focal plane from real observations*
T.Zwitter, U.Munari

17:30 —— Coffee Break

18:00 *RVS spectra computed from real PSF (including TDI blurring)*
V. Cayatte, F. Royer, D. Katz

18:30 *RV accuracies from PSF computed spectra*
A. Sellier, M.O. Baylac, D. Katz

19:00 *Requirements to recover the formation history of the galaxy from halo stars kinematics*
A.Helmi

19:30 —— Dinner

February 8

9:00 *Telemetric flow*
D. Morin, Y. Viala

9:30 *The GAIA Data Access and Analysis System. A Review*
S. Ansari

10:00 *GAIA and the pulsating stars*
G. Bono

10:30 —— Coffee Break

11:00 *New grids of ATLAS9 model atmospheres*
F.Castelli

11:30 *Radial velocities in SIMBAD and VIZIER at CDS*
F.Crifo

11:45 *The accuracy of rotational velocity determination*
U.Munari, T.Zwitter

12:00 —— Lunch

12:50 —— Departure to Venice for its "Carnevale in Maschera"

20:30 —— Dinner in Bassano

23:30 —— Return to Asiago

February 9

9:00 *Expected results from photometry*
C.Jordi

9:30 *A 6-dimension, 10^5 entries syntethic spectral database for RVS*
T.Zwitter, F.Castelli, U.Munari

9:45 *Real pectra databases*
R.Sordo, U.Munari

10:00 —— Coffee Break

10:30 *Modelling of eclipsing binary stars*
A.Prsa

11:00 *Recent results on DIB 8620 Ang*
U.Munari

11:15 *Open discussion on what needs to be done in coming months*

12:30 —— End of the Meeting

GDAAS: the GAIA Data Access Analysis Study

S. Ansari, ESTEC

The GAIA Data Access Analysis Study (GDAAS) was initiated to assess current trends in technology to handle large amounts of data (expected to reach 150 Terabytes), to simulate an end-to-end processing chain and to investigate performance issues. The ESA Contract is being run by a Software Company (GMV), the University of Barcelona and CESCA, an infrastructure partner. Based on a Hierarchical Triangular Mesh Database architecture and currently running on Objectivity, this first phase of the study, which has implemented two sets of algorithms for a Global Iterative Solution (L. Lindegren) and Source Cross Matching (M. Lattanzi et al.) for the ASTRO instruments has proven to be very useful in setting the scene for more complex simulations in the upcoming phases. Performance tests cover simulations of 6 hours of mission down to 20th magnitude along the galactic plane to a full 5-year mission run down to 13th magnitude. It is expected that the simulations of RVS data will be the prime objective of the next phase of the study in order to quantify the overall data processing effort and telemetry budget for the GAIA mission.

Gaia and the pulsating stars

G. Bono, INAF/ Rome Astronomical Observatory

We present current observational and theoretical scenario for radial variables and in particular on Classical Cepheids and RR Lyrae stars. We outline the impact that such objects have on the cosmic distance scale and on the age of Galactic globular clusters. At the same time, we discuss the key role that the coupling between evolutionary and pulsation properties play to constrain stellar parameters.

We focus our attention on empirical uncertainties affecting current distance determinations and in particular on reddening. Reddening corrections are a long-standing and thorny problem, since the intrinsic color of RR Lyrae and Cepheids is redder if they are extincted ”or” if they are more metal-rich. This means that it is mandatory to supply and independent reddening estimate to split this degeneracy.

Finally, we mention the impact that future spectroscopic data collected by GAIA will have on variable stars. As a matter of fact, the detection and measurement of the diffuse interstellar band at λ=8620 Å seems a promising and foresighted approach to settle down this problem.

A new Grid of ATLAS9 Model Atmospheres

F. Castelli, IAS/CNR Rome and Astron. Obs. of Trieste

A new grid of ATLAS9 model atmospheres computed for metallicity [Fe/H]=0.0 and micro-turbulent velocity V_{turb}=2 km sec^{-1} is presented. The new models are based on updated line opacities. The new opacities and the different results between the old and the new models are briefly discussed.

Radial Velocities available via SIMBAD and VIZIER at CDS

F. Crifo, Paris-Meudon Observatory

The already available radial velocities were examined in the SIMBAD data base and in VIZIER (catalogue section of the CDS).

- In SIMBAD (Data Base organized by ASTRONOMICAL OBJECTS, and containing data extracted from the PUBLISHED astronomical literature): about 45000 radial velocities are registered in the "fundamental data" for stellar objects (bibliographic reference given). Of them: about 10000 are cluster stars or variable stars; several thousands are objects WITHOUT coordinates (cluster objects numbered on a chart)

  – Distribution in magnitude: bulk between 5 and 12 in V; up to 22.

  – Distribution in RV: bulk between –50 and +50 km/s; from –996 up to +920km/s.

  – Distribution in σ(RV): 17500 stars without σ(RV), but a good part with a "quality" indicated by a letter (inhomogeneous); mostly "round" values at 0.9; 2; 5; 10 and 20 km/s; 19000 stars with error $\leq$5 km/s; 3000 with error $\leq$1 km/s.

- In VIZIER: only the largest compilation catalogue was examined in details: RV catalogue from Barbier-Brossat and Figon (2000), containing 36144 stars (14502 stars with σ(RV), 21642 without)

  – Distribution in magnitude: bulk between 5 and 12 in V; up to 22.5

  – Distribution in RV: bulk between -50 and +50 km/s; from -99.9 to +583

  – Distribution in σ(RV): of the 14502 stars with error: 12300 stars with error $\leq$5 km/s; 5100 with error $\leq$1 km/s

Field-rotation/distortion and filter issues for GAIA-RVS

M. Cropper, Mullard Space Science Laboratory

We have investigated whether the GAIA-RVS optical design by Matra Marconi Space can be modified (*a*) to allow the mechanism rotating the detector subsystem can be moved to the grism, which would avoid the difficulties posed by the electrical and thermal connections to the focal plane, and further, (*b*) whether the mechanism can be removed entirely. We find that both of these goals can be achieved.

The solution relies on a tighter control of the spatial distortions in the system, and on the spatial variation of the dispersion. This allows the dispersion direction to be in the scan direction, rather than perpendicular to it. The slight variations in the angle of the scan tracks then result in much more acceptable spatial rather than spectral smearing, if no mechanism is used. If a mechanism is retained, then this spatial smearing can be eliminated.

We find that the mechanism can indeed operate on the grism if the grism is rotated about an appropriate axis. Should this fail, the failure mode (spatial rather than spectral smearing) is more graceful.

We also looked briefly at increasing the field of view from the 1x1 deg in the study to the current 2x1 deg baseline, and concluded that this would require an increase in the scale of the instrument if the current design was maintained, especially as the 1x1 deg field is already vignetted. Regarding an increase in the spectral resolution, our preliminary conclusions were that this should be feasible from optical considerations.

Finally we reported on issues regarding the bandpass filters used to define the spectral range used in RVS. We considered filter specifications and possible vendors, and also some of the requirements for the filter rejection ratios to prevent contamination.

GAIA PWG activities

C.Jordi, Dept. of Astronomy, University of Barcelona

The activities of the PWG are centered on the photometric system (PS) design, the technical implementation and the reddening determination capabilities.

The PS design will be optimized for the scientific targets according to the GAIA scientific goals. The set of scientific targets as well as the criteria against which different PS proposals will be evaluated is being elaborated. Once defined and agreed, the most reliable spectra (either synthetic or observed) for those targets will be identified.

The present status of the compilation of synthetic spectra may be found in PWG web site (http://gaia.am.ub.es/PWG). A critical comparison and evaluation of the available spectra will be performed. A proposal for computation of models with alpha-enhanced abundances has been submitted.

While synthetic spectra are very useful to evaluate differential changes in the spectral features, its is also true that they are not suitable to describe several kind of stars. In collaboration with other GAIA WGs, observed spectra for these kind of stars will be identified in the literature or acquired on ground.

Simulations with Hipparcos-Tycho data show that the 3-D diffuse ISM distribution may be mapped from rough reddening-free colour indices (MBP) of well defined tracers followed by accurate parallaxes and BBP. Data from other space missions may be useful.

An alternative proposal to the gates strategy for bright stars has been proposed by E. Hoeg. It consists on sampling the wings of the PSF. Impact on telemetry is under study.

Triangular filter profiles have been proposed as an option for the BBP concerning chromaticity correction. The feasibility of this profile is under study, too.

Finally, the PWG web site includes a photometry simulator. It allows computation of number of counts and associated magnitude errors for a given star, interstellar absorption, radial velocity, sky background and instrument model. The user can change the instrument design to play with his own options. Several additional capabilities are planned for the next future.

Requirements to recover the formation history of the Galaxy from halo stars kinematics

A. Helmi, MPA Garching

We run numerical simulations of the disruption of satellite galaxies in a Galactic potential to build up the entire stellar halo. We generate artificial GAIA halo catalogues, in which we look for the signatures left by the accreted satellites. We develop a method based on the standard Friends-of-Friends algorithm applied to the space of integrals of motion. We test different magnitude limits and accuracies for the radial velocity to determine how the recovery rate of these accretion events depends on these parameters. We find that we can recover

- 1/2 of the different accretion events, assuming a velocity error of 15 km/s at V=15;
- 2/3 of the events, if we include all "stars" (assumed to be giants with M_V=1), with distance errors less than 20% and velocity (tangential and radial) errors $<$20 km/s, and a limiting magnitude V=18.5.

The number of "stars" with good kinematics (i.e. errors less than 10 or 20 km/s), are limited mostly by the distance errors, which for a halo giant at 10 kpc (V=15) are of the order of 10%, translating into an error in the tangential velocity of 20 kms, to be compared with the expected radial velocity error at V=15, of $\sim$5 km/s.

We thus conclude that our results do not strongly depend on the resolution of the spectrograph, although large samples of halo stars (relatively faint magnitudes, e.g. V = 18) are always required.

GAIA spectrometric instrument design

D. Horville, F. Sayede, Paris-Meudon Observatory
(presented by D.Katz)

The main specifications of the first feasibility study of the RVS instrument, performed by MATRA, were : a field of view of 1×1 deg and a resolution R = 5 000 over the wavelength range 8470–8700 Å. Since this study the foreseen characteristics of the RVS have evolved to those summarized in the "Concept and technology study report" : a FoV of 2×1 deg, a resolution in the range R = 5 000 to 20 000 over a spectral interval slightly shifted toward the red 8490–8740 Å. The present work is a feasibility/optimization study of this second configuration (here considering the case R = 10 000 with 10×10 μm pixels). The MATRA design has been modified in order to accomodate the distorsions with the larger FoV and resolution. The resulting system displays small optical distorsions with respect to the PSF FWHM, thus showing its viability : (i) an anamorphose of 4%, (ii) a trapezium-like distorsion of 212 μm from top to bottom of the CCDs and (iii) a maximum spectrum orientation variation of 5 μm.

RVS spectra computed from real PSF (including TDI blurring)

D. Katz, D. Horville, F. Sayede, F. Royer, V. Cayatte, Paris-Meudon Obs.

The objective of the present study is to simulate RVS spectroscopic data, that takes into account the optical distorsions of the instrument, as well as the TDI charge transfer mode of the CCD. This is done in two steps. First, monochromatic PSFs, at different wavelengths, are propagated over the CCD, according to the motion of a star during its crossing of the field of view. The results, are monochromatic *transit PSF*, i.e. PSFs after one transit integration time, whose shapes have been elongated by the spectrum orientation variation, the star line curvature and the TDI smearing. The various optical distorsions depend on the across scan position of the star during its transit and so do the *transit PSFs*. Once several of them have been derived for different wavelengths, the RVS spectrum is reconstructed (second step) by convolving the *transit PSFs* by a high resolution reference spectrum, either observed or synthetic.

RV accuracies from PSF computed spectra

D. Katz, A. Sellier, M.O. Baylac,   Paris-Meudon Observatory

The *theoretical* RV accuracies, as function of magnitude and source type, achievable with a spectrograph having the foreseen characteristics of the RVS instrument (resolution in the range 5 000, 20 000 over the wavelength range 8490–8740 Å) have been estimated both from observed (Munari et al., 2001) and synthetic spectra (Katz et al., 1999, Zwitter et al., 2002). Here we investigate, how the optical distorsions and TDI mode affect previous estimation of the RVS performances (in the case of a G3V solar metallicity star). This is done by Monte-Carlo approach, starting from an RVS simulated spectrum (see the "RVS spectra computed from real PSF (including TDI blurring)" abstract) and repeating 1000 to 2000 times the following steps : (i) addition of noises (according to the magnitude) and (ii) cross-correlation with a synthetic template. The preliminary results seems to show that (i) the optical distorsions do not modify significantly the random error, but (ii) that an under-sampling of the PSF FWHM (less than 2 pixels per resolution element) or a small slope of the spectrum between its blue and red edge both generate systematic errors.

Telemetric flow of the RVS instrument

D. Morin, Y. Viala, D. Katz, F. Arenou, F. Crifo, C. Turon
and A. Gomez-Stefanovitch,   Paris-Meudon Observatory

The first step in getting the telemetry budget of the RVS instrument requires an estimation of the distribution of stars (up to the limiting magnitude $G = 19$) throughout the whole sky as well as the variation with time of the field of view (1x1 deg) of the intrument during the whole GAIA mission. Our first aim is to compute, as a function of time, the number of stars scanned by RVS during the time interval Δt, ranging from 0.008 s (two successive CCD readings) to 5 years (duration of the GAIA mission). The star distribution will be determined from the GSC-II catalog, obtained from 1" resolution scans of the photographic Sky Survey plates and containing nearly half a billion of objects with positions and magnitudes in the photographic F (0.71 μm) and J (0.44 μm) bands. After converting F and J magnitudes to G (GAIA) magnitudes and extrapolating down to G=19 (G=22 for ASTRO1 and ASTRO2), stars will be counted, by magnitude intervals, within boxes of 1x1 deg centered every degree in galactic coordinates (2000) over the ranges $-90 < b < 90$ and $0 < l < 360$ deg. Tables giving number of stars per square degree and magnitude interval $n(l, b, \Delta m)$ as a function of galactic coordinates will be provided to the community. The GAIA Nominal Scanning Law (Lindegren : SAG-LL-14, SAG-LL-30 and SAG-LL-35) allows us to determine the position of the field of view of the RVS instrument versus time during the GAIA mission, and hence to compute, from tables $n(l, b, \Delta m)$, the number of stars scanned by the instrument. As a preliminary result, we show what is obtained for the first day of scanning (arbitrarily starting from J2000) : positions (l, b) of the 2880 successive fields of view of 1x1 deg and number of stars counted in each of them from the GSC-II catalog (only true stars have been selected). Extension of this work is planned to cover the whole GAIA mission and any scanning time interval and to get the telemetric flow for the other two instruments ASTRO1 and ASTRO2.

On the accuracy of RVS determination of rotational velocities

U. Munari, INAF - Padova and Asiago Astronomical Observatory
T. Zwitter, Dept. of Physics, University of Ljubljana

The prospects of GAIA measurement of projected rotational velocities ($V_{rot} \sin i$) are reviewed. The G-break characterizes the $V_{rot} \sin i$ distribution over the HR diagram, in having O, B, A and F stars rotating up to several hundred km sec^{-1}, but 90% of all G, K, M, Carbon and S stars confined to $V_{rot} \sin i \leq 20$ km sec^{-1}.

However, most of the GAIA targets will be G, K, M stars, and at least a raw measure of their projected rotational velocities would be relevant in dealing with their nature.

From simulations on synthetic spectra as well as observations of real cool stars of known projected rotational velocity, it is found that RVS spectra at 0.25 Å/pix can classify G, K, M stars in at least three $V_{rot} \sin i$ bins: stars rotating at less than 10 km sec^{-1}, stars rotating between 10 and 20 km sec^{-1}, and stars rotating faster than 20 km sec^{-1}. On the other hand, RVS spectra at lower dispersion have no such possibility.

So to retain at least a minimum measure capability of $V_{rot} \sin i$ in cool stars, it is necessary that RVS will record its spectra at a dispersion of at least $\sim$0.25 Å/pix.

Recent results on the diffuse interstellar band 8620 Å

U. Munari, INAF - Padova and Asiago Astronomical Observatory
T. Zwitter, Dept. of Physics, University of Ljubljana

The diffuse interstellar band at 8620 Å has been found to be a reliable reddening tracer. A first calibration gives (Munari 1999, in *Molecules in Space and in the Laboratory*, I.Porceddu and S.Aiello ed.s, Conf.Ser.Ital.Soc.Phys. 67, 179, or astro-ph/0010271): $E(B-V) = 2.69 \times E.W.$, where $E.W.$ is the equivalent width (in Å) of the DIB 8620 Å. Since then, observations have been continued along several viewing directions in the Galaxy, to the aim of refining the relation in terms of $E(B-V) = \alpha(l,b,distance) \times E.W.$, by relating $\alpha(l,b,distance)$ to the local properties of the interstellar medium. Reduction and analysis of the large amount of collected data should be ready by the end of the year. In the meantime, promising validations of the $E(B-V) = 2.69 \times E.W.$ have been obtained in recent observations of almost unique objects in the Galaxy, like the *Red Rectangle* or the misterious object V838 Mon, characterized by violent outbursts, complex circumstellar geometry and robust mass-loss reminiscent of final helium flash conditions. For V838 Mon (cf. Zwitter and Munari 2002, IAU Circ. 7812) the insterstellar NaI D and KI lines indicated a total extinction toward V838 Mon of $E(B-V) = 0.80 \pm 0.02$ using interstellar line calibrations in Munari and Zwitter (1997, A&A 318, 269). On the same spectra the DIB 8620 Å presents an E.W. of 0.30±0.01 Å, laying exactly on the $E(B-V) = 2.69 \times E.W.$ relation.

On modeling of eclipsing binaries

A. Prsa, Dept. of Physics, University of Ljubljana

Most models of eclipsing binaries depend on photometry and spectroscopy. Special thought is given to other techniques, such as polarimetry, magnetometry and Doppler profile mapping, which could noticeably improve the model quality.

Our adopted model handles three aspects of eclipsing binaries: physics and geometry of the orbit and components, intensity calculation and flux calculation. Each in turn have been presented to acknowledge possible problems and deficiencies. We gave an overview of physics that governs some specific lightcurve and radial velocity curve effects: gravity brightening, limb darkening and reflection effect. A concise summary of black body vs. model atmosphere approach has been given. It was suggested that perturbative corrections due to stellar spots and circumstellar matter modeling introduces strong degeneracy and is thus unappropriate without solid proof of existence of such regions.

A table of available EB related software has been presented with their individual highlights and pitfalls. We demonstrated that Wilson-Devinney code WD98 currently holds the top position. Extensive effort is being made to enhance WD code even further in a unifying PHOEBE project.

Real spectra databases

R. Sordo, U. Munari   INAF - Padova and Asiago Astronomical Obs.

A long term project aimed to cense available spectral databases is approacing completion in Asiago. More than a hundred and fifty databases (in both electronic and tabular varieties) have been surveyed in the ultraviolet, optical and infrared.

Each database is documented by a devoted card, summarizing selected items like: (*a*) aims, basic references and type of data provided, (*b*) λ range, dispersion, resolution, sampling, (*c*) number of objects, their spectral types and luminosity classes, (*d*) type of detector/instrument and fluxes, (*e*) link to the data. The card also provides a plot with a spectrum typical for the given database, and three histograms showing the distribution in spectral type, luminosity class and metallicity of the objects included in the given database.

The final census will be released in book format as soon as checks and controls will be completed (presumably by time of the Monte Rosa conference in coming September). An associated web interface for ad hoc interrogations should be operative soon after that.

A 6-dimension, 10^5 entries synthetic spectral database for RVS

T. Zwitter,   Dept. of Physics, University of Ljubljana
U. Munari,   INAF - Padova and Asiago Astronomical Observatory
F. Castelli,   IAS/CNR Rome and Astron. Obs. of Trieste

A status report on the final synthetic spectra database for RVS simulations based on the ATLAS9 model atmospheres is provided. The computations carried out in a coordinated way at Asiago, Ljubljana and Trieste are almost completed for normal [α/Fe] ratios.

For each temperature, a completed grid mapping generously in surface gravity, metallicity, rotational velocity and spectral dispersion is provided (about 6750 spectra for each T_{eff}).

Recomputation of the spectra for different [α/Fe] ratios will be added when the new $\alpha-$enhanced model atmospheres will become available.

Crowding in the RVS focal plane from real observations

T. Zwitter, Dept. of Physics, University of Ljubljana
U. Munari, INAF - Padova and Asiago Astronomical Observatory

We use accurate and deep V and I photometry of over 100 fields around a sample of symbiotic stars (Henden and Munari 2000, A&AS 143, 343; 2001 A&A 372, 145; 2002 A&A, in preparation) to assess star density and distribution down to the GAIA faintness limit. We find that star density at $V > 15$ is well described by a heuristic $dN/dm \propto 2.3^{V-(V-15)^2/20}$ law. Star density of $V < 17$ stars per square degree is compatible with the values of 1200 (for $|b| >$20 deg) and 6100 (for $|b| <$20 deg), with only 3 fields reaching a density of 40000 stars with $V < 17$ per square degree. Moreover we explore the sampling law and establish the well known fact that arrangement of stars in the focal plane will be different at each of the $\sim$ 100 passages, providing that the spin and precession periods are kept uncomensurable. These data are then used to assess the problem of spectral cuts at CCD edges and of spectral overlaps. While the first effect can be handled by a proper instrument design the crowding is unavoidable. Assuming that the spectral tracing has a width of 1 arcsec we estimate the degree of crowding at various star densities. We show that for a star density of 1200 $V < 17$ stars per square degree (value typical away from the galactic plane) there is a 10% chance that the head of the next tracing of a $V < 17$ star starts 1200 arcsec behind the first star's tracing head. This means that spectral overlap will only marginally affect the spectra even if the highest (R=20000) spectral resolution is chosen. The problem naturally worsens if we consider overlaps of faint ($V < 19$) stars on a ($V < 17$) star tracing close to the galactic plane: there would be a 50% chance for an overlap if the spectral length is 500 arcsec (figure compatible with a R=10000 resolution). This figure may seem high but one should bear in mind that we are accustomed to effectively disentangle spectra of even very badly mixed cases, i.e. those of spectroscopic binary stars. We conclude that crowding is frequently present but never problematic, except for the very dense fields in the galactic plane with star densities of over 10^4 ($V < 17$) stars per square degree.