FROM 1000 AU TO 1000 PC: HIGH PROPER-MOTION STARS IN THE SOLAR NEIGHBOURHOOD, RADIO SOURCES IN THE $\sigma$ ORIONIS CLUSTER, AND NEW X-RAY STARS SURROUNDING ALNILAM

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ABSTRACT

The Virtual Observatory is useful. I summarise some of my works where I extensively use the Aladin sky atlas. Topics cover from the search and common proper motion confirmation of very low-mass stars and brown dwarfs in wide ($\rho > 1000$ AU) binaries and multiple systems, to the identification and characterisation of stellar and substellar populations in young open clusters and OB associations at heliocentric distances of up to 1000 pc. I present three practical examples of what one can do with Aladin in one morning: a fruitful proper-motion search of objects with available $ugrizJHK_s$ photometry, an analysis of the 21 cm radio sources towards the young $\sigma$ Orionis cluster, and a novel study of X-ray young stars surrounding Alnilam in the Orion Belt.

Key words: astronomical data bases: miscellaneous; stars: binaries: visual; stars: low mass, brown dwarfs; Galaxy: open clusters and associations: individual: $\sigma$ Orionis, Collinder 70; X-ray: stars.

1. INTRODUCTION

What is the Virtual Observatory (VO)? One may pompously answer that it is "an international astronomical community-based initiative that aims to allow seamless access to distributed astronomical resources, and to provide the necessary tools to analyse data and produce scientifically relevant results[1]." Another one may be sharper and more optimistic, and answer that it is "the Universe in your computer". The use of available astronomical data archives of space and ground-based observatories and sky survey databases is widespread in Astronomy. As an example, to date (2008 Jan), the SAO/NASA Astrophysics Data System lists almost 900 refereed papers with the title words “Sloan Digital Sky Survey” (SDSS). *Hipparcos* parallaxes, digitisations of the Palomar Observatory Sky Survey (POSS), and near-infrared magnitudes from the Two-Micron All Sky Survey (2MASS) are also used very often. However, surveys, missions, and consortia like them are not the VO, but data providers that follow common standards given by the VO.

What I know is what is not VO. It is not applying for telescope time, travelling to a remote observatory, having sleepless nights, nor reducing and calibrating data when back to office. Thus, being a “virtual observer” is a cheaper, more ecological, and less time-wasting way of doing Astronomy (how many telescope nights have you lost due to bad weather? how many hours have you spent at the airport?). Obviously, the VO will not kill the classical observing mode. On the contrary, VO is the perfect complement to telescope facilities of all sizes.

In this proceeding, I alternate an “egocentric” summary of my VO-related publications and three basic, practical examples of what one can do with my favourite VO tool: the Aladin sky atlas (Bonnarel et al. 2000). The common denominator of the examples is that they can be fully accomplished in just a few hours (less than a working day) and are scientifically interesting.

2. PROPER-MOTION SURVEYS

When I serendipitously discovered Koenigstuhl 1 AB (Kö 1 AB; Caballero 2007a), only one very low-mass binary with a projected physical separation $s$ larger than 100 AU was known, DE0551–44 AB (Billères et al. 2005). With $s \approx 220$ AU and a total mass $M_A + M_B < 0.2 M_\odot$, DE0551–44 AB represented a challenge to many low-mass star formation scenarios. The projected physical separation between the two components in Kö 1 AB, although having roughly the same total mass as DE0551–44 AB, was one order of magnitude larger, $s = 1800\pm170$ AU, which made it to be by far the widest low-mass binary. Two years later, Kö 1 AB has been surpassed only by 2M0126–50 AB ($s = 5100\pm400$ AU; Artigau et al. 2007). The two components in Kö 1 AB,
LEHPM 494 and DE0021–42, were previously known as late-type, high-proper-motion stars, but had not been associated because of their faintness and relatively large angular separation of $\rho \sim 1.3$ arcmin. I identified Kő 1 AB as a binary candidate during a routine visual inspection with Aladin and confirmed their common proper-motion with public data (2MASS, DENIS, SuperCOSMOS digitisations of UK Schmidt plates). New telescope observations were unnecessary.

In Caballero (2007c), I extended the search for low-mass stars and brown dwarfs in wide binaries and multiple systems and measured for the first time the common proper motion of two new wide systems containing very low-mass components, Koenigstuhl 2 AB and 3 A-BC. The two of them are among the widest systems in their respective classes (e.g. the faintest component in Kő 3 A-BC is the most separated L dwarf to its primary, $s = 11900\pm300$ AU). In addition, I determined the frequency of field wide multiples with late-type components and measured for the first time the proper motions of 62 field stars and brown dwarfs with spectral types $\textit{M}5.0\textit{V}$. All the presented results came from on-line catalogues and archival images, without complementary observations.

New proper-motion surveys aimed at the detection and characterisation of wide binaries are on-going in collaboration (Caballero et al. 2008b) or alone (Caballero, in prep.). The basics of these surveys are the extensive use of proper-motion catalogues (USNO-B1. Tycho-2) with the Aladin sky atlas and will be described in detail elsewhere.

### 2.1. SU2 = SDSS + USNO-B1 + 2MASS

The first practical example is a pilot Aladin-based search for high-proper motion objects. One of the disadvantages of most proper motion surveys is the poor follow-up characterisation of the identified objects. Classical surveys have provided tentative spectral types based on colours and magnitudes from photographic plates (e.g. Giclas et al. 1971; Luyten 1979). Low-resolution spectroscopy is available for a tiny fraction of the numerous high-proper motion dwarf, subdwarf, and white dwarf candidates identified so far. The combination of $V$-band magnitudes estimated from photographic $B_J$ and $R_F$ magnitudes and near-infrared magnitudes from 2MASS as in Salim & Gould (2003) or Lépine & Shara (2005) helps a lot in the classification of these objects, but it is still insufficient. One way of avoiding this handicap is surveying areas where there exists plenty of accurate multiband photometry.

I give the name SU2$^3$ to this pilot survey because I use astro-photometric data from the SDSS, USNO-B1, and 2MASS catalogues. Sources in the three catalogues have tabulated coordinates, proper motions, and magnitudes in the $ugrizJHK_s$ bands (apart from the photographic $B_JR_FB_W$ bands). Given the nature of this publication, I will be “pedagogical” in the description of the SU2 survey. What follows has done with Aladin v4, but can be done in the same way with the most recent release Aladin v5.015. The survey has been carried out in a 1 deg-radius circular area centred on $12 00 00 +30 00 00$ J2000, but could have done elsewhere with available SDSS, USNO-B1, and 2MASS data. The high galactic latitude of the field, $b \sim 78$ deg, minimises the number of systematic errors of USNO-B1 proper motions in crowded fields. Studying a larger survey area is feasible, but the data loading might slow down the whole process. The common steps of the analysis have been as follow:

- With the Aladin Server selector, load two images taken at different epochs. Although one can manage without them, background images facilitate enormously the source identification. Instead of loading one of the Aladin images (e.g. $1.7 \times 1.7$ deg$^2$ E-DSS1), I recommend loading Digitized Sky Survey images from ESO (Garching) in the DSS button. They take longer to be loaded, but their spatial resolution is highly improved. Load, for example, $120 \times 120$ arcmin$^2$ DSS1 POSS1-Red/UKST-Blue and DSS2 POSS2UKSTU-Red images centred on the above coordinates. In this case, epochs of observations were J1955.275 (DSS1) and J1991.261 (DSS2).
- Load all Simbad sources at 1 deg to the central coordinates (button Simbad in Catalogs column).

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$^3$Do not mistake with the special unitary group of degree 2, SU(2).
• Load all 2MASS sources at 1 deg to the central coordinates (button Surveys in Catalogs column, pick up 2MASS).

• Load all USNO-B1 sources (button Surveys, pick up USNO-B1).

• Load all SDSS sources (button Surveys, pick up SDSS-DR6 – note that it is the sixth SDSS data release). They may take up to one minute to be loaded.

• In the Tools button, open the Catalog cross-match tool. Cross-match 2MASS and USNO-B1 (in this order) with the default threshold in source separation (4 arcsec) and match method (best matches).

• Cross-match the previous output (XMatch result1) with SDSS. Afterwards, to save computer memory, one can delete planes in the Aladin plane stack and leave only the DSS1 and DSS2 images (one can do a blink sequence with the right mouse button).

• Select all the sources in the XMatch result2 plane. In the Tools button, open VOpplot (the VO-India 2-D plotter for selected objects). For clarity, one can plot a proper motion diagram (pmDE in Y axis, pmRA and active reversal, Rev, in X axis).

• In the VOpplot window, create a new data subset with the button Create new filter. Enter data subset name (whatever: e.g. Rosebud) and condition. I used the following condition:

\[
\sqrt{\left(\frac{\mu_\alpha^2 \cos \delta + \mu_\delta^2}{2}\right)^{1/2}} > 100 \text{ mas} \, \text{a}^{-1} \quad \text{and} \quad J < 15.5 \, \text{mag}
\]

which translates into \((\mu_\alpha^2 \cos \delta + \mu_\delta^2)^{1/2} > 100 \text{ mas} \, \text{a}^{-1}\) and \(J < 15.5 \, \text{mag}\). The magnitude restriction is to minimise the number of faint sources with spurious high proper motions (the great majority of high-proper motion star candidates with \(J > 15.5 \, \text{mag}\) turn out to be USNO-B1 errors with \(\mu \approx 0\) when studied in detail – e.g. by comparing DSS1 and DSS2 images).

• In the VOpplot window, select all the sources in the new data subset. They are marked in the Aladin view window and are displayed in the measurement window. One can export the results in ascii to a file with the Aladin script console in the Tools button or investigate each source in the measurement window just with a few mouse clicks.

There are 32 sources that satisfy the proper motion and \(J\)-band magnitude requisites. After visual inspection, I discarded two of them because of incorrect USNO-B1 proper motions: one is a Zwicky galaxy in a group of galaxies and the other one is a background double source with null proper motion. The remaining 30 sources have marked non-zero proper motions in the DSS1 and DSS2 images (one can do a blink sequence with the button Image associations [asoc] in the tool bar). I also checked the consistency of proper motions of several targets as tabulated by USNO-B1 and the SuperCOSMOS Science Archive (Hambly et al. 2001). Of the 30 objects, seven are bright stars and saturate or are in the non-linear regime in at least the SDSS \(i\) and \(z\) images. The two brightest stars, HD 104379 (HIP 58615) and BD+30 2204, saturate at all SDSS passbands. There is spectral type determination at F8–G5 for five of them (Schwassmann & van Rhijn 1947). The remaining two bright stars, G 121–36 and 2MASS J120125.09+295057.1, seem to be nor-

3It is discussed here for the first time. Coordinates: 12 01 25.09
Next, I focus on the 23 high proper-motion objects that do not saturate in the SDSS images. Of these, 17 are new and six had been previously detected by Giclas et al. (1965; one object), Luyten (1979; three), and Lépine & Shara (2005; two). With the available proper motion and photometric data (ugrizJHK_s), I have constructed several diagrams to ascertain the nature of the 23 objects. In Fig. 1 I show two of these diagrams: an SDSS-based colour-colour diagram to the left, and the g-band reduced proper motion as a function of the colour g − J to the right. Reduced proper motion is defined as \( \mu_g \equiv g + 5 \log \mu + 5 \) (\( \mu \) in arcsec a\(^{-1}\)), while the colour g − J is an indicator of effective temperature. All the high proper motion objects except five have reduced proper motions and SDSS-2MASS colours typical of M2–6 dwarfs in the field (Lépine & Shara 2005; West et al. 2008). The five exceptions are listed in Table 1. The bluest outlier is GD 147, which was reported by Giclas et al. (1965) as a promising white dwarf suspect. Two previously unknown objects are located close to GD 147 in the two diagrams in Fig. 1 and are classified in this proceeding as white dwarf or blue subdwarf candidates. For naming them, I have followed the “Albus” (white) nomenclature introduced by Caballero & Solano (2007). White dwarf GD 147 is more than two magnitudes brighter than Albus 2 and 3 in the GALEX NUV (near-ultraviolet) passband, indicating a possible subdwarf nature for the latter. The other two outliers are LP 320–47 and a new object, for which I have followed the “Ruber” (red) nomenclature introduced by Caballero & Solano (2008). The latter star has red-optical and near-infrared colours typical of ∼M0 dwarfs, but redder colours at bluer wavelengths (ugr). This fact and its red g − J colour for its reduced proper motion may indicate a subgiant phase. Last, an abnormally low metallicity may be responsible of the peculiar optical colours observed in LP 320–47. A dedicated spectroscopic follow-up is needed to ascertain the nature of this unusual object.

### 3. THE σ ORIONIS CLUSTER: A SPACE ODYSSEY

The brightest star in the σ Orionis cluster (\( \tau \sim 3 \) Ma, \( d \sim 385 \) pc) is the eponymous σ Ori multiple system, which is famous for illuminating the Horsehead Nebula. The cluster is the richest hunting ground for young low-mass brown dwarfs and planetary-mass objects (substellar objects with theoretical masses below the deuterium burning mass limit) and an important region for investigating youth features in stars, such as X-ray emission, jets, photometric variability, or discs (see a bibliographic review in Caballero 2008b). However, the σ Orionis stellar population was relatively poorly known a few years ago.

The Aladin-based cross-match between Tycho-2 and 2MASS in Caballero (2007b) was the first effort to build a comprehensive list of bright stars in the σ Orionis cluster. Membership status of each star was based on optical and near-infrared colours and magnitudes, proper motions, IRAS infrared excesses, X-ray emission, and spectroscopic data from the literature. Collateral results in this work were the first determination of the mass function and the disc frequency in the high mass domain of the cluster and the astrometric confirmation of overlapping of different young star populations in the Orion Belt.

In Caballero (2008b), I extended the catalogue of cluster members, candidate members, and non-members towards the limit imposed by the i-band depth of the Deep Near Infrared Survey of the Southern Sky (DENIS). The basis of the work was an optical/near-infrared correlation between the 2MASS and DENIS catalogues in a circular area of radius 30 arcmin centred on σ Ori AB. The analysis was supported by an exhaustive bibliographic search of confirmed cluster members with signposts of youth.
and by additional X-ray, mid-infrared, and astrometric data. The output of the search, the Mayrit catalogue of \( \sigma \) Orionis stars and brown dwarfs, has turned out to be a very useful tool for studying the spatial distribution (Caballero 2008a; Bouy et al. 2008), disc frequency as a function of mass (Luhman et al. 2008), initial mass function and multiplicity (Caballero 2008c; N. Lodieu et al., in prep.), X-ray emission (López-Santiago & Caballero 2008; Caballero et al. 2009; E. Francisoni et al., in prep.), and spectroscopic properties of cluster low-mass stars and brown dwarfs (Caballero et al. 2008a; A.-M. Cody et al., in prep.). The preparation of an updated version of the Mayrit catalogue, with UKIDSS photometry, spectral types, radial velocities, and Li I \( \lambda \)670.8 nm pseudo-equivalent widths, is on-going (Caballero 2008c).

### 3.1 Radio sources towards \( \sigma \) Orionis

In the course of radio-continuum observations of a small sample of hot stars, Drake (1990) detected a faint (probably non-thermal) radio emission at 2, 6, and 20 cm coming from the pair \( \sigma \) Ori AB in the centre of the \( \sigma \) Orionis cluster. He found a significant radio to optical positional offset of 2.1 arcsec. The explanation for this discrepancy came when van Loon & Oliveira (2003) found a mid-infrared source that is a proto-planetary disc being dispersed by the intense ultraviolet radiation from \( \sigma \) Ori AB. The X-ray and near-infrared counterparts of the star in the densest part of the dust cloud was afterwards discovered by Sanz-Forcada et al. (2004) and Caballero (2005), respectively. This star, known as \( \sigma \) Ori IRS1 (Mayrit 3020 AB), is actually double (Bouy et al. 2008). The free-free radio emission arises from a photo-ionized region at the interface between the radiation field of \( \sigma \) Ori AB and the dust cloud. Previously, Drake et al. (1987) had found non-thermal radio emission from \( \sigma \) Ori E, a magnetic, B2Vp, He-rich star at only 42 arcsec to \( \sigma \) Ori AB. In this case, the emitting volume is non-spherical and co-rotates with the star (\( \dot{P} = 1.19 \text{ d}; \) Leone & Umana 1993). Density fluxes at centimetric wavelengths of both \( \sigma \) Ori AB and E are relatively low, of about a few millijansky (Wendker 1995). Finding stronger radio emitters in the cluster would ease the determination of its parallactic distance via very long baseline interferometry at the Orion Nebula Cluster (Sandstrom et al. 2007; Menten et al. 2007). Unfortunately, no third cluster radio emitter is known to date. Drake (1990) reported another three radio sources in the vicinity of \( \sigma \) Ori AB ([D90] 1, 2, and 3), while Caballero et al. (2007) presented a faint, red, near-infrared source at 1.5\( \pm \)1.0 arcsec to another relatively bright radio source (TXS 0537–029). The four sources seem to have extragalactic nature, especially the latter, for which Caballero et al. (2007) identified the possible host galaxy.

In the second VO practical example, I have used Aladin to look for the possible 2MASS counterparts of the sources in the 1.4 GHz National Radio Astronomy Observatory Very Large Array Sky Survey (NVSS; Condon et al. 1998) at less than 30 arcmin to \( \sigma \) Ori AB. I carried out a methodology similar to that presented in Section 2.1, but cross-matching the NVSS and 2MASS catalogues using a threshold in source separation of 10 arcsec. Fig illustrates this search. The nine cross-matched NVSS radio sources are listed in Table 2. Among the non-cross-matched NVSS sources, there are two radio sources discussed above ([D90] 1 and TXS 0537–029). Of the cross-matched sources, three are associated to faint extended sources with a likely extragalactic nature. Another two radio sources are surrounded by a number of faint blue optical sources with USNO-B1/2MASS colours typical of unresolved galaxies, which might form clusters of galaxies. In these cases, it is difficult to ascertain which is the actual origin of the radio emission. The second brightest NVSS source in Table 2 is associated to a known galaxy with hard X-ray emission and a power-law photon index consistent with it being a Seyfert galaxy with a supermassive black hole (2E 1448; López-Santiago & Caballero 2008). There remain three NVSS radio sources. In two cases, the closest 2MASS source is a \( \sigma \) Orionis cluster member in the Mayrit catalogue. In the third case, a Mayrit star is the second closest 2MASS source, only a few arcseconds further than the one listed in Table 2. Below, I enumerate the three of them:

- **NVSS 053911–023236**, at \( \rho = 6 \pm 10 \text{ arcsec} \) to Mayrit 425070 (S Ori J053911.4–023333). The 2MASS possible counterpart is a very low-mass cluster star with Li I in absorption and low gravity spectral features, but it lacks a disc (Caballero 2008b and references therein). No H I 21 cm line is expected to come from this object; it may come from an unidentified background galaxy instead.

- **NVSS 053957–022613**, at \( \rho = 5.5 \pm 1.0 \text{ arcsec} \) to 2MASS J05395766–0226083 and \( \rho \sim 9.4 \text{ arcsec} \) to the confirmed cluster member Mayrit 1245062 (S Ori J053958.1–022619). Despite its Li I absorption and moderate H\( \alpha \) emission, the accretion disc surrounding Mayrit 1245062 cannot be dense and hot enough to emit with a density flux of more than 20 mJy.

- **NVSS 053755–023305**, at \( \rho = 2.7 \pm 1.3 \text{ arcsec} \) to Mayrit 757283 (S Ori 35). On the contrary to the other two stars, the disc surrounding Mayrit 757283 is apparent in Spitzer observations at 8 \( \mu \text{m} \) (Hernández et al. 2007). However, the possible two-lobe 1.4 GHz emission, the significant positional offset, and the intensity of the radio emission may indicate a possible extragalactic nature.

To sum up, \( \sigma \) Ori AB+IRS1 and \( \sigma \) Ori E remain as the only known radio emitters in the \( \sigma \) Orionis cluster.

### 4. NEW HUNTING GROUNDS FOR BROWN DWARFS

Numerous populations of brown dwarfs and planetary mass-objects have been found in other young star-
forming regions different from the σ Orionis cluster, such as ρ Ophiuchi, Chamaeleon I, or the Orion Nebula Cluster, but not in so large quantities. Besides, the much lower extinction in σ Orionis facilitates the spectro-photometric follow-up for confirmation of cluster membership. Very few σ Orionis analogues ($d < 0.5$ kpc, $\tau < 10$ Ma, $A_V < 1$ mag) do exist, like the Collinder 69 cluster around λ Ori in the Orion Head.

Two of these σ Orionis analogues were identified and characterised for the first time by Caballero & Solano (2008). They catalogued about 500 young stars and candidates surrounding the OB supergiants Alnilam (ε Ori – in the Collinder 70 cluster) and Mintaka (δ Ori) in the Orion Belt. Procedures and membership selection criteria, based on cross-matches of the Tycho-2, DENIS, and 2MASS catalogues with Aladin and construction of colour-magnitude and proper-motion diagrams, were very similar to those used by Caballero (2007b, 2008b) in the Mayrit catalogue. Many new detections of stars with near- and mid-infrared excesses due to circumstellar discs and X-ray emission arised from the survey.

Except Taurus, all star-forming regions where young brown dwarfs have been found have in common the presence of early-type stars that ionise the interstellar medium (e.g. all clusters above plus NGC 2264, IC 2391, Pleiades...). Therefore, looking for new sites for substellar searches is synonymous with looking for agglomerates of early-type stars. Following this idea, Caballero & Dinis (2008) studied the spatial structure and substructure of regions rich in Hipparcos stars with blue $B_T - V_T$ colours. The exhaustive all-sky analysis of the membership in agglomerate of the 406 selected stars was carried out with Aladin. Most of the 35 identified agglomerates were associated to previously known clusters and OB associations. Brown dwarfs have been searched for in a significant fraction of these agglomerates (e.g. Orion Nebula Cluster, Pleiades). We listed seven agglomerates (including NGC 2451A, vdBH 23, Trumpler 10, and the new, nearby, young, open cluster P Puppis) as new sites for substellar searches. The brown dwarf populations of some of these agglomerates await discovery and are suitable to be analysed with Aladin.

4.1. X-ray sources in Collinder 70

Several young stars and candidates surrounding Alnilam and Mintaka in the survey by Caballero & Solano (2008) are X-ray emitters detected by the Einstein, ROSAT, and XMM-Newton space missions. Nevertheless, the great majority of them had never been reported in the literature. In the third and last VO practical example, I complement that survey with the identification of the optical and near-infrared counterparts of X-ray sources in the XMM-Newton Serendipitous Source Catalogue (2XMM) surrounding Alnilam.

Again, the basis of this analysis was an Aladin-based cross-match between 2XMM and 2MASS catalogues in the core of the Collinder 70 cluster. Of the 78 2XMM sources in the area, 52 have a 2MASS source within a threshold in source separation of 10 arcsec. Among them, one is an active F4V star in the foreground and nine are X-ray galaxies. The extragalactic nature of some of the latter objects is patent from 2MASS photometry, DSS images, or alternative multi-wavelength data (e.g. [In the course of this survey, Caballero & Solano (2007) serendipitously identified Albus 1 (CPD–20 1123), one of the brightest He-B subdwarfs yet found (Vennes et al. 2007).]
Table 3. X-ray T Tauri stars surrounding Alnilam with colours \( J - K_s \) $>$ 1.2 mag.

| Name     | \( \alpha \) (J2000) | \( \delta \) (J2000) | \( \rho \) [arcsec] | \( J \) [mag] | \( K_s \) [mag] | \( F_X \) \( [10^{-17} \text{ W m}^{-2}] \) |
|----------|----------------------|----------------------|--------------------|--------------|---------------|----------------|
| Kiso A–0904 41 | 05 35 53.49          | −01 23 04.4          | 0.94               | 12.65±0.02   | 11.43±0.02    | 4±3            |
| StHA 47   | 05 35 22.93          | −01 11 24.3          | 0.19               | 10.457±0.019 | 9.18±0.02     | 18±4           |
| V583 Ori  | 05 36 35.15          | −01 02 16.8          | 0.86               | 12.12±0.02   | 10.881±0.019  | 4±3            |

Figure 3. X-ray “luminosity function” of young stars in the Alnilam region. Fluxes and luminosities are related through a \( 4\pi d^2 \) factor (where \( d \sim 0.4 \text{ kpc} \) is the heliocentric distance of Collinder 70).

The three X-ray T Tauri stars, listed in Table 3, are the reddest young stars in my sample and have colours \( J - K_s \) $>$ 1.2 mag. This fact, together with the detection of the H\( \alpha \) line in strong emission (Haro & Moreno 1953; Stephenson 1986; Wiramihardja et al. 1989 – V583 Ori is also a known photometric variable), supports the disc scenario. The X-ray emission from Kiso A–0904 41 and V583 Ori is faint, as expected in T Tauri stars with absorbing discs (e.g. Neuhauser et al. 1995). However, the disc around StHA 47, which has a stronger X-ray emission, may be face-on (see some examples of face-on discs in \( \sigma \) Orionis in López-Santiago & Caballero 2008). All these detections deserve a careful analysis of the original XMM-Newton data that will be presented in a forthcoming publication.

5. THE FUTURE IS BRIGHT!

With Aladin and a little of imagination, one can do a lot of interesting science. However, I have only a vague idea of what one will be able to do when the data from future deep, multi-wavelength, all-sky surveys will be available through Aladin. The next generation of ground-based surveys is here: RAVE \[\text{http://www.rave-survey.aip.de}\], UKIDSS \[\text{http://www.ukidss.org}\], SDSS-III \[\text{http://www.sdss3.org}\], Pan-STARRS \[\text{http://pan-starrs.ifa.hawaii.edu}\], and LSST \[\text{http://www.lsst.org}\]. But the “virtual” revolution will come with next all-sky space missions, such as NASA’s WISE \[\text{http://wise.ssl.berkeley.edu}\] (launch November 2009) and, especially, ESA’s GAIA \[\text{http://gaia.esa.int}\] (launch December 2011). Do not keep still in the
mean time!

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REFERENCES

Artigau É., Lafrenière D., Doyon R. et al. 2007, ApJ, 659, L49
Billères M., Delfosse X., Beuzit J.-L. et al. 2005, A&A, 440, L55
Bonarel F., Fernique P., Bienaymé O. et al. 2000, A&AS, 143, 33
Bouy H., Huélamo N., Martín E. L. et al. 2008, A&A, in press, eprint [arXiv:0808.3890]
Caballero J. A. 2005, AN, 326, 1007
Caballero J. A. 2007a, A&A, 462, L61
Caballero J. A. 2007b, A&A, 466, 917
Caballero J. A. 2007c, ApJ, 667, 520
Caballero J. A. 2008a, MNRAS, 383, 375
Caballero J. A. 2008b, A&A, 478, 667
Caballero J. A. 2008c, Proceedings of the 15th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, eprint [arXiv:0810.2029]
Caballero J. A. & Dinis L. 2008, AN, 329, 801
Caballero J. A. & Solano E. 2007, ApJ, 665, L151
Caballero J. A. & Solano E. 2008, A&A, 485, 931
Caballero J. A., Béjar V. J. S., Rebolo R. et al. 2007, A&A, 470, 903
Caballero J. A., Valdivielso L., Martín E. L. et al. 2008a, A&A, 491, 515
Caballero J. A., Miret F. X., Genebrier J. et al. 2008b, Proceedings of the VIII Scientific Meeting of the Spanish Astronomical Society, eprint [arXiv:0810.2030]
Caballero J. A., López-Santiago J., de Castro E., Cornide M. 2009, AJ, submitted

Condon J. J., Cotton W. D., Greisen E. W. et al. 1998, AJ, 115, 1693
Drake S. A. 1990, AJ, 100, 572
Drake S. A., Abbott D. C., Bastian T. S. et al. 1987, ApJ, 322, 902
Giclas H. L., Burnham R., Thomas N. G. 1961, LowOB, 5, 61
Giclas H. L., Burnham R., Thomas N. G. 1965, LowOB, 6, 155
Giclas H. L., Burnham R., Thomas N. G. 1971, Lowell proper motion survey Northern Hemisphere. The G numbered stars. 8991 stars fainter than magnitude 8 with motions > 0.26/year. Flagstaff, AZ: Lowell Observatory
Hambly N. C., MacGillivray H. T., Read M. A. et al. 2001, MNRAS, 326, 1279
Haro G. & Moreno A. 1953, Bol. Obs. Tonantz. Tacub., 1g, 11
Hernández J., Hartmann L., Megeath T. et al. 2007, ApJ, 662, 1067
Leone F. & Umana G. 1993, A&A, 268, 667
Lépine S. & Shara M. M. 2005, AJ, 129, 1438
van Loon J. Th. & Oliveira J. M. 2003, A&A, 405, L33
López-Santiago J. & Caballero J. A. 2008, A&A, 491, 961
Luhman K. L., Hernández J., Downes J. J., Hartmann L., Briceño C. 2008, ApJ, 688, 362
Luyten W. J. 1979, LHS catalogue. A catalogue of stars with proper motions exceeding 0.5 annually. Minneapolis, MN: University of Minnesota
Menten K. M., Reid M. J., Forbrich J., Brunthaler A. 2007, A&A, 474, 515
Neuhäuser R., Sterzik M. F., Schmitt J. H. M. M., Wichmann R., Krautter J. 1995, A&A, 297, 391
Salim S. & Gould A. 2003, ApJ, 582, 1011
Sandstrom K. M., Peek J. E. G., Bower G. C., Bolatto A. D., Plambeck R. L. 2007, ApJ, 667, 1161
Sanz-Forcada J., Franciosini E., Pallavicini R. 2004, A&A, 421, 715
Scholz A. & Eislöffel J. 2005, A&A, 429, 1007
Stephenson C. B. 1986, ApJ, 300, 779
Vennes S., Kawka A., Smith J. A. 2007, ApJ, 668, L59
Wendker H. J. 1995, A&AS, 109, 177
West A. A., Hawley S. L., Bochanski J. J. et al. 2008, AJ, 135, 875
Wiramihardja S. D., Kogure T., Yoshida S., Ogura K., Nakano M. 1989, PASJ, 41, 155