Light and Motion in SDSS Stripe 82

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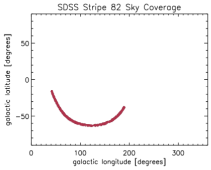
Introduction

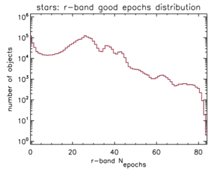


The SDSS Stripe 82 is the region spanning from 20^h to 4^h in right ascension and from $-1^\circ.25$ to $1^\circ.25$ in declination, the sky coverage is shown in galactic coordinates in the left panel.

The stripe has been repeatedly imaged between June and December since 1998, a distribution of number of good epochs is shown in the right panel and we see that the number of good observations is high for a large fraction of the data.

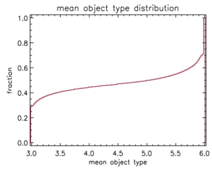
The high number of observations that exist for each object make the stripe ideal for the study of variability and proper motions. To this end, Bramich et al. (2007, in prep) have created a Light-Motion-Curve Catalogue (LMCC) containing light-curve data for all stars and galaxies in the stripe that pass certain "good" selection criteria, and a Higher Level Catalogue (HLC) containing a set of 241 derived quantities for each light-motion-curve in the LMCC.

Here we investigate certain properties of the catalogues and use the catalogues to select variable stars.



Stars & Galaxies

Distinguish between stars and galaxies using mean object type.



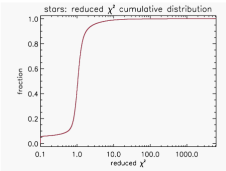
Each object is assigned an object type when it is observed; 3 if it is galaxy-like and 6 if it is star-like. For repeated observations, the mean object type is the unweighted mean of the assigned object types.

A cumulative distribution of mean object type for the catalogue reveals that ~55% of objects are purely galaxy-like or purely star-like, having a mean object type of 3 or 6. The remaining 45% of objects lie in between. In order to select variable stars, we must first split the catalogue into stars and galaxies. The slope of the cumulative distribution changes at mean object type 4.5 so we take this as our cut value.

Henceforth in this analysis, galaxies are objects with a mean object type less than 4.5 and stars are objects with mean object type greater than or equal to 4.5.

Constants & Variables

Distinguish between constant stars and variable stars using reduced χ^2.



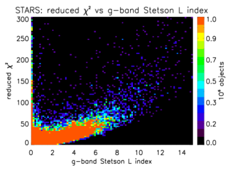
In compiling the HLC, only observations flagged as good are used in calculating the derived quantities. SDSS data are taken in five bands: *u, g, r, i* & *z*. For each band, the HLC contains χ^2 for a constant fit and the number of good epochs. Summing these two quantities for all bands and taking the ratio gives the reduced χ^2 for all bands.

A cumulative distribution of reduced χ^2 is shown to the left. We use the point at which the slope turns over as a cut between constant and variable stars.

This cut considers 95% of stars to be constant and 5% of stars to be variable, and the value of the cut is for a reduced χ^2 value of 2.7.

True Variables & Artefacts

Distinguish between true variable stars and artefacts using g-band Stetson L index.



The objects which we have classed as variables may be one of two types of objects:
1 - truly variable stars
2 - non-variable stars with outliers and artefacts.

We use the *g*-band Stetson L index (Stetson, 1996) as a proxy for variability. The Stetson index looks for correlations between two or more sets of data – this might be data taken in two (or more) bands, or data taken in the same band.

For the HLC, two-band Stetson indices were calculated for each band, using the *r*-band as the reference; as such, the Stetson index is 0 for all objects in the *r*-band. In general, the *g*- and *r*-bands have the highest number of good epochs; L_r is 0, as discussed, so L_g is chosen to assess true variability.

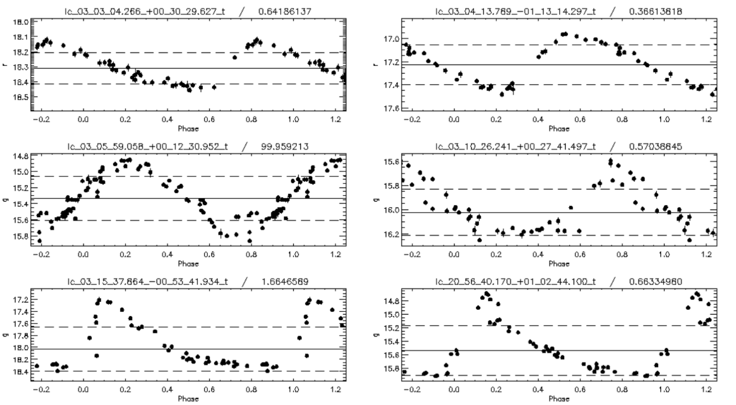
A density plot of reduced χ^2 vs. L_g, see left, shows two distinct populations:
· one for which the relationship is linear and which we believe are true variables and,
· one for which objects have high reduced χ^2 and low L_g indicating that they are artefacts and not true variables.

Sample Lightcurves

Find variable periods using a periodogram and plot folded lightcurves

We use a Lomb-Scargle periodogram to obtain period estimates for those identified as being truly variable and then plot folded lightcurves using the periods obtained. A selection of representative lightcurves are shown to the right.

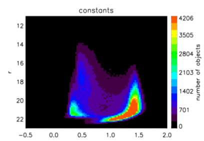
In each case, periods have been estimated using the band for which there was the highest number of good data points; the lightcurves have also been plotted in this band. The lightcurve name and period estimate are shown in the graph title.



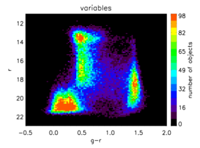
Colour-Magnitude Diagrams

r vs *g-r* for constants, possible variables and true variables

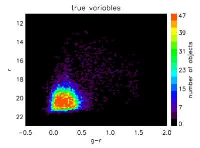
The *r*-band magnitudes and *g-r* colours were used to plot a colour-magnitude diagram for the various subsets; these are shown below where pixel colour represents the number of objects in each pixel bin.



CMD for stars identified as constant considering reduced χ^2. We identify three over-densities:
· the largest on the bottom right we identify with thin disk stars
· the medium clump on the bottom left we associate with halo stars and
· the small clump towards the top left we identify as thick disk stars.



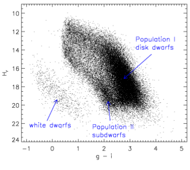
CMD for all objects classified as variable by their reduced χ^2. Again, we see three distinct populations associated with thin disk, thick disk and halo stars in the same locations as for the constants.
There is also an fourth clump in the diagram above the thick disk population; this is most likely caused by saturated stars..



CMD for all objects believed to be truly variable, based on their reduced χ^2 value and their *g*-band Stetson L index. We are left now with one clump, that associated with halo stars.

Future Work

Investigate spatial distribution and kinematical properties of different classes of variable.



Now that we have a set of variable stars, we can use colour-cuts to find particular types of known variables.

We plan to use the colour cuts described in Ivezic et al. (2005) to select RR Lyrae candidates from our variable star subset. As RR Lyraes are standard candles, this provides us with distances. Combined with proper motions, this will enable us to trace substructure in the halo – such as the Sagittarius and other streams – as well as possibly dwarf galaxies.

Additionally, we plan to study the spatial distribution and kinematical properties of number of classes of variable star including miras, long period variables, and semi-regular variables.

Finally, we plan to construct a reduced proper motion diagram (left panel, see Vidrih et al., in prep) to study the kinematical properties of white dwarfs and Population I and Population II subdwarfs.

References

Bramich D. M., et al., 2007, MNRAS, in preparation

Ivezic Z., et al., 2005, AJ, 129, 1096

Stetson P. B., 1996, PASP, 108, 851

Vidrih S., et al., 2007, MNRAS, in preparation

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Milky Way Halo Conference, Bonn 2007, Poster 22