The APM Northern Sky Catalogue

Over the last few years we have been using the APM facility to measure the first epoch Palomar O and E sky survey plates, with the eventual aim of constructing a readily accessible Northern sky optical catalogue. The first phase of this project, concentrating solely on high galactic latitude fields (those with galactic latitudes 30 degrees or more away from the plane) has now been successfully completed. Consequently, we now have available a catalogue covering half the Northern sky, including the zero declination strip, and covering some 10,000 square degrees of sky. The catalogue contains well over 100 million objects down to limits of 22nd magnitude in O and 20th magnitude in E. The sky coverage of the catalogue is shown in the accompanying diagram, using the original token Palomar field centres for convenience.

The purpose of this article is to announce the availability of this catalogue for general astronomical use and to briefly describe how it was set up and what it contains.

1. Some Details of the Measuring

An area of 6.2 x 6.2 degrees for each of some 600 glass copy survey plates was scanned on the APM at a sampling interval of ½ arcsec. Detected images were parameterised in the usual way such as to preserve coordinate, intensity and general shape information (second moments, peak intensity, areal profile at eight logarithmically-spaced levels). By only saving these image parameter lists plus a coarse ½ mm resolution pixel map of the plate background, considerable data compression results, with the 4 Gbyte of data per plate being compressed by a factor of 200 to around 20 Mbytes (or around 12 Gbytes for the complete raw Phase I catalogue).

1.1 Astrometry

All plates were initially aligned with respect to PPM astrometric standards before scanning, using the standard APM real-time lining up procedure which invokes a six plate constant linear model plus standard Schmidt radial distortion. An area of a few mm around each target is scanned and a Gaussian fit to 1D marginal sums of the intensity distribution suffices to define the x-y table coordinates of the star. Generally only the brightest 15 standards per field are used at this point. The effect of this is to essentially align the plate with respect to the diffraction spikes of the standard stars. However, since the astrometry for the general purpose image detection used in scanning a plate is based on image moments (i.e. centre of gravity) a second astrometric alignment is automatically made using all the PPM stars on the plate. On average there are well over 200 PPM stars per field and we find a typical rms error for our simple linear plate model of around 0.5 arcsec. The rms error of the PPM stars is approximately 0.25 arcsec and the rms error in measuring the centre of gravity of a heavily saturated bright star is at least that. Diffraction spikes give much smaller rms errors but are systematically biased with respect to the star centre of gravity as a function of position of the star on the plate.

1.2 Photometry

The O passband is approximately equivalent to U + B (3200 – 4800 A) whilst the E passband corresponds to a narrow R (6300 – 6900 A). To a very good approximation, the colour O - E = 2(B - V) over a large range of colours, $0 < B - V < 1.5$, making the colour information available for the Northern sky extremely valuable and at the present time, unique in all-sky surveys.

The analysis threshold for both O and E plates was essentially defined by the average plate sky noise. This meant that we generally ended up setting a detection threshold of around 24 mag/sq arcsec for the O plates and around 23 mag/sq arcsec for the E plates. The dynamic range of the survey glass copies is very low since these plates were deliberately contrast enhanced for ease of eyeball inspection (sky is set at around 0.5 D, the plates saturate before 2 D, whilst the sky noise — mainly due to the large grain size of the originals — is around 0.1 D/sq arcsec). As a result of this the plate emulsion response is highly non-linear and of course for these plates there are no calibration

wedges — which at least in one sense simplifies matters greatly.

Internally consistent magnitudes were derived using the scheme described by Bunclark and Irwin (1983). This produces a sensible linear magnitude system for stellar images by making use of the fact that the stellar profile should be consistent with a single point spread function irrespective of object magnitude, or indeed position on plate. The position of the blue edge of the stellar locus in an E, O – E colour-magnitude-diagram provides a simple method of calibrating the O-E colour, accurate to about 0.1 magnitudes, whilst simply assuming a constant depth for the survey plates gives an approximate zero-point for the magnitude system. (When sufficient Northern sky calibration becomes available we will of course fold this into the catalogue.) For galaxies the semi-major axis diameter provides an alternative measure of luminosity.

1.3 Image Classification

Images were morphologically typed as either stellar, non-stellar, blended or noise, using all the image parameter shape information. The classifier utilises 'fuzzy' decision making logic to place an object in a given category and quantifies how stellar-like each image is in terms of an N(0,1) stellar distribution as a function of magnitude.

The large grain size on the original plate material coupled with the low signal-to-noise near the plate limit renders the image classification 'objectively unreliable' at around a magnitude above the plate limit. However, brighter than this the added bonus of both the colour information and two independent estimates of the image classification make up for the relatively coarse grain size compared to modern emulsions. Specifying the 'accuracy' or 'completeness' of the image classification is singularly misleading but for those with a penchant for numerology a figure of 90% is representative.

2. Some Details of the Catalogue

In producing the final version of this Phase I catalogue we were driven by the requirement of ease of use for assorted astronomical projects and by a not incompatible desire to further compress the size of it. Consequently the final catalogue has undergone the following steps: firstly both plates for a field were matched up in order to produce a list of paired up images — the only requirement for an image match being positional coincidence to within 2 arcsec; secondly all non-matching images for both O and E plates were retained — for obvious reasons; finally after much astronomical soul-searching we retained only the following parameters for all O and E images: image classification category and stellarness index, x and y plate coordinates, magnitude, semi-major axis radius at detection isophote, ellipticity, and ellipse position angle. Each uniquely detected image has this information packed into 24 bytes with no loss of critical accuracy. (Clearly some images have both O and E data, some E only and some O only). Typically 100,000 images match up on both O and E plates and roughly the same number again do not match up for various reasons. This version of the catalogue occupies approximately 3 Gbytes — a further factor of 4 compression giving a total reduction in storage of nearly a factor of 1000 from the original plate material.

The catalogue is arranged on a field by field basis, with one file per field, and is archived in declination strips. Each file contains a file header block which provides the necessary information to convert to celestial coordinates — currently B1950 — but if demand warrants it we can readily produce a J2000 version.

Needless to say, both the original raw data tapes and various intermediate versions of the catalogue have been retained to cover the few pathological projects impossible with the fully compressed catalogue.

3. Some Details of Use and Availability

The main driving force behind this undertaking was not community altruism, but the need to urgently produce in a reasonably short timescale an optical database that could be used for various optical identifications projects in the Northern sky. It has already been extensively used for various ROSAT X-ray identification projects, IRAS infra-red surveys and an ever growing number of Radio

based identification programs. This of course is only the tip of the astronomical iceberg and the potential uses of a database such as this are essentially unlimited: ranging from the trivial — producing thousands of finding charts for large area survey work or coordinates for multifibre spectrographs — to the more bellicose such as modelling the stellar population of our Galaxy or analysing the large scale distribution of galaxies/clusters.

3.1 Installation

Currently the catalogue is 'installed' on a microVax 4000 VLC system, with two dedicated 1 Gbyte data disks and an exabyte tape drive. The archive/storage medium is via multiple VMS backup savesets (one saveset per declination strip) such that no more than 1 Gbyte is archived per exabyte tape — simplifying data archive and retrieval operations. Assorted analysis software and DCL command procedures enable essentially automatic interrogation of the entire catalogue or parts thereof and indeed the slowest part of the operation is generally printing/plotting the results.

3.2 Availability

At the present time we are not distributing copies of the entire catalogue. However, potential users will be given access to smaller subsets for their own use. We will either provide users with a copy of the relevant subset plus software, so that they may undertake their own processing, or within reasonable limits we can carry out the processing in Cambridge and relay the results. Users who have projects requiring access to a significant fraction of the entire database are encouraged to contact one of the persons named below to discuss the possibility of a collaborative venture.

3.3 Future plans

We are currently fine tuning the 'user' interface to the VMS system and would also like to gauge demand for a UNIX-based version of the catalogue plus interrogation software and command procedures. At the present time the low cost and widespread availability of exabyte tape systems make this our preferred distribution medium. However, we would also be interested in comments on alternative media, such as CD roms.

Scanning of lower galactic latitude fields down to within 20 degrees of the plane is well underway and will soon be incorporated within the catalogue. Finally as indicated earlier, future versions of the catalogue will hopefully be based on real photometry, although to be honest, the internal calibration is good enough for most purposes.

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