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A Study of the Variability and Proper Motions of Quasars based on Tautenburg Schmidt Plates

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Abstract. We report on the present status of an ongoing study of variability and proper motion of quasars based on Tautenburg Schmidt plates of the field around M3. The main aspects are: (i) a thorough investigation of variability of a sample of known quasars based on a large number of B plates with a long time baseline and the comparison of variability in U, B, and V; (ii) the variability - proper motion diagram for the objects with B $\lesssim$ 20.5 mag in this field and the loci of known quasars in this diagram. The primary aim of this work is to check the suitability of Tautenburg Schmidt plates for a combined variability - proper motion quasar survey.

1. Introduction

The search for variable objects in fields at high galactic latitudes provides an efficient method to detect quasars. Based on UKST plates, recent work (Hook et al. 1991; Hawkins 1993; Hawkins and Veron 1993) has shown that Schmidt plates are well-suited for variability surveys for quasars. Majewski et al. (1991) combined a variability survey with a proper motion survey in a 0.3 deg^2 field on plates from the KPNO 4 m telescope. It seems that the search for objects which are both variable and stationary is a powerful finding method for quasars. The plate material from the 134 cm Tautenburg Schmidt telescope is expected to provide a good basis for both variability and proper motion studies, because the available plates cover a long time baseline for some selected fields. In 1993 a corresponding program has been started at Tautenburg which is focused on the field around the globular cluster M 3. This paper reports on the present status of the pro;ect.

2. A Study of Variability in U, B, V

In a first step, variability of a sample of 20 quasars and 9 quasar candidates from published catalogs (Hewitt and Burbidge 1987, 1989; Veron-Cetty & Veron 1989; Crampton et al. 1990) was studied. Magnitudes were measured on 88 B plates, 26 U plates and 30 V plates using the Tautenburg semi-automated iris

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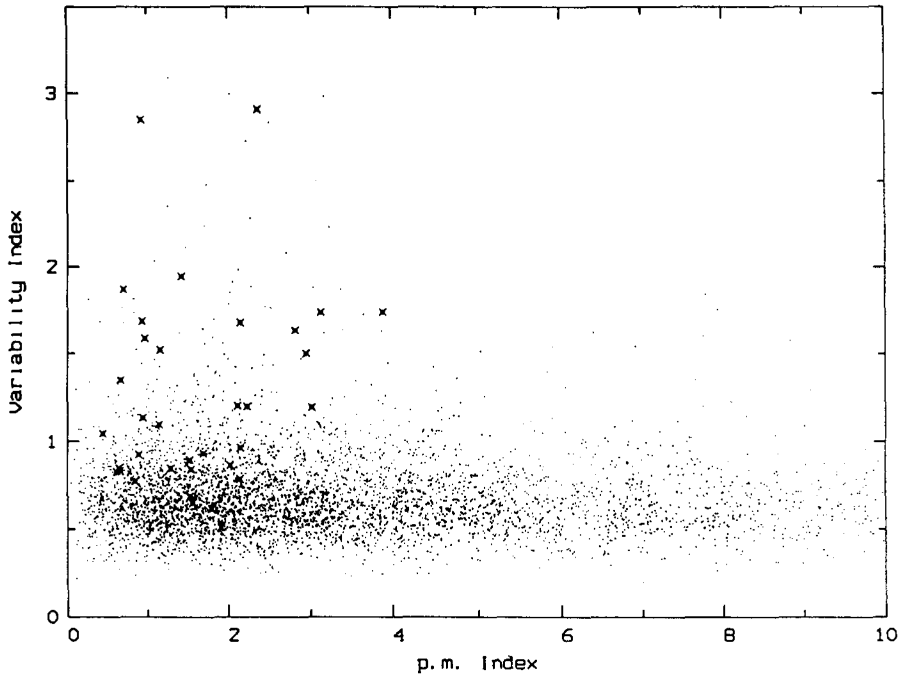

Figure 1. Variability index versus proper motion index for the 4766 objects in the M3 field with B $\geq$ 17 mag, lying outside the immediate globular cluster region, being measured on all 10 plates and classified as stellar. Two objects have variability indexes > 3.5 and are, therefore, not shown in this diagram. The quasars from the studied sample are plotted as x.

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photometer. The time baseline amounts to nearly three decades. Furthermore, 10 B plates (also with a long time baseline) have been scanned with the APM, Cambridge, UK.

The results from the B data were already reported elsewhere (Meusinger et al. 1994a,b). The following gives a brief summary: both variance and structure function analysis have been applied. The measured variability was corrected for the magnitude-dependent "instrumental" contribution. The question whether an object is variable or not was decided by means of statistical tests. The fraction of quasars with detected variability is about 65–85 % at a high level of confidence. Timescales of the dominant variability mode have been roughly estimated from the structure functions. There are indications for a significant long-term variability with timescales probably up to the length of the time baseline, or even longer.

The analysis of the data from the 10 plates scanned with the APM is based on rather poor statistics. Nevertheless, the results from the variance analysis of the APM data agree quite well with those based on the larger number of plates measured with the iris photometer. For about 80 % of the measured objects the results of the variability classification (i.e. variable or not) are identical.

The comparison of the variability in U, B, and V suggests: (i) it is unlikely that the variabilities measured in the three bands are completely uncorrelated; (ii) variability is, in a statistical sense, stronger in U than in B; and stronger in B than in V.

3. The Variability - Proper Motion Diagram

A second quasar sample was constructed on the basis of the catalog of Hewitt and Burbidge (1993). This sample consists of 35 quasars which were measured on each of 10 plates scanned with the APM and which were classified as stellar by the APM facility. These objects provided the basis for studying the variability - proper motion diagram.

Proper motions of the objects in the M 3 field are available due to the work of Scholz et al. (1993). The proper motion data have been determined using a stepwise regression method with 3rd order polynomials in the plate-to-plate solutions with about 2000 reference galaxies. The results were corrected for systematic errors dependent on position and magnitude of the objects. The accuracy is 2–3 mas/yr for B $\leq$ 19 mag.

Following Majewski et al. (1991), we defined a variability index by averaging $\mid \Delta B_k \mid / s_k(B)$ over all measured plates. $\mid \Delta B_k \mid$ is the absolute value of the difference between the the average magnitude and the magnitude measured on the plate k and $s_k(B)$ is the standard deviation of B on the plate k. For an object with magnitude B the proper motion index was formulated as the proper motion in units of the standard deviation of the proper motions for all objects with the same apparent magnitude B.

For about 90 % of the studied quasars the estimated variability index is larger than the mean variability index for all measured objects, but for only 50–60% is it significantly larger. This result is probably influenced by the small number of measured plates. The quasars are strongly concentrated toward low proper motion indices. For the other objects, 9 out of 65 with variability indices

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≥ 1.5 exhibit large proper motion indices (≥ 4) and can be rejected, therefore, from the list of quasar candidates. There were 20 objects found with variability indices ≥ 2. It seems remarkable that for all but one, the estimated proper motion index is smaller than 4.

4. Next Steps

We intend to improve the variability statistics in the M 3 field by scanning a larger number of plates. Furthermore, almost all objects with significant variability exhibit small proper motion indices; this should be checked by similar studies in other fields. By using the Tautenburg multi-object camera TAUMOK (see Marx et al. 1994) we expect to check spectroscopically the brightest candidates from this variability - proper motion study.

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