ASTRONOMY & ASTROPHYSICS
SUPPLEMENT SERIES

Astron. Astrophys. Suppl. Ser. **121**, 247-253 (1997)

UBV photometry of galactic foreground and LMC member stars

II. Galactic foreground stars (supplement)*,**

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Received February 2; accepted March 26, 1996

Abstract. In addition to the list of *UBV* photometries of 955 galactic foreground stars in the direction to the Large Magellanic Cloud published by Gochermann et al. (1993a), a supplement of 545 stars is presented, which have been measured with the same photometric accuracy. Moreover, less reliable photometries of 379 further foreground stars are listed in a separate table. The homogeneous data base of more than 1 500 high accuracy photometries represented by these stars has been used to construct a reddening distribution map of the galactic foreground towards the LMC by Oestreicher et al. (1995).

Key words: catalogues — Galaxy: stellar content — galaxies: Magellanic Clouds

1. Introduction

Gochermann et al. (1993a; hereafter Paper I) have published high accuracy *UBV* photometries of 955 galactic foreground stars in the direction to the Large Magellanic Cloud. These stars were mainly selected from the catalogues of LMC foreground and member stars compiled by Fehrenbach & Duflot (1970, 1973, 1974, 1981, and 1982) and others (cf. Paper I). The photometries are part of a comprehensive data base presently (January 1996) containing the available information on more than 7 100 LMC member stars, nearly 3 300 galactic foreground stars, and about 330 stars of uncertain membership (Gochermann et al. 1993b; Gochermann et al. 1995).

The present publication (Paper II) contains a supplement of *UBV* photometries of altogether 924 further galactic stars in front of the LMC, which have not been listed in Paper I, and of which no reliable *UBV* photometries have been published before. As a first application of the photometries published in Papers I and II, a high resolution (10′) galactic foreground reddening map towards the LMC has been constructed by Oestreicher et al. (1995).

2. Observations and data reductions

All observations listed in Tables 2 and 3 were carried out at the Bochum 61 cm and the ESO 50 cm telescopes at La Silla, Chile, from November 1990 to January 1994. A complete journal of observations is given in Table 1. Details on the technical realization of the *UBV* photometric systems (photomultipliers and filters) can be found in Paper I. The equipment used at the Bochum Telescope for the periods 1992/93 and 1993/94 is identical to that introduced in November 1991 (EMI 9789 B photomultiplier).

Photometric standard stars, and first and second order atmospheric extinction coefficients were always measured as described in Paper I. In 1993/94 no second order extinction coefficients were determined at the Bochum Telescope, but the values taken from the 1992/93 observations ($k''_v = -0.014$, $k''_{bv} = -0.038$, $k''_{ub} = -0.004$). After the Mt. Pinatubo volcanic eruption in June 1991, always daily first order extinction coefficients were applied to reduce the data in order to account for intermittently ocurring large fluctuations of the atmospheric extinction (cf. Paper I). A clear trend of the extinction could be noticed from 1991 to 1994 due to the "fall–out" of Pinatubo volcanic

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* based on observations collected with the Bochum 61 cm and the ESO 50 cm telescopes at La Silla/Chile.
** Tables 2 and 3 only available in electronic form.

Table 1. Journal of Observations (Photometric systems: J = Johnson, C = Cousins)

Date	Telescope	System	Observer
26.11.90–02.12.90	Bochum 61	J	Gochermann
03.12.90–18.12.90	Bochum 61	J	Grothues
04.12.90–19.12.90	ESO 50	C	Gochermann
09.11.91–04.12.91	Bochum 61	J	Grothues
19.11.91–04.12.91	ESO 50	J	Gochermann
05.12.91–07.01.92	Bochum 61	J	Oestreicher
08.01.92–11.02.92	Bochum 61	J	Berghöfer
14.11.92–12.12.92	Bochum 61	J	Tappert
13.12.92–20.01.93	Bochum 61	J	Oestreicher
16.11.93–13.12.93	Bochum 61	J	Zaum
14.12.93–18.01.94	Bochum 61	J	Brugger

dust from the atmosphere, with the average first order extinction coefficients, k'_v, decreasing from 0.21 ± 0.02 in 1991/92, over 0.19 ± 0.03 in 1992/93, to finally 0.15 ± 0.03 in 1993/94. The last value is still larger than the average coefficient of $k'_v = 0.130 \pm 0.014$ found in 1990, before the eruption (Paper I; Grothues & Gochermann 1992).

Transformations of the photometries to the Johnson and Cousins *UBV* systems, averaging of all measurements of each star from different nights, and the determination of errors and qualities, were also performed exactly in the way described in Paper I.

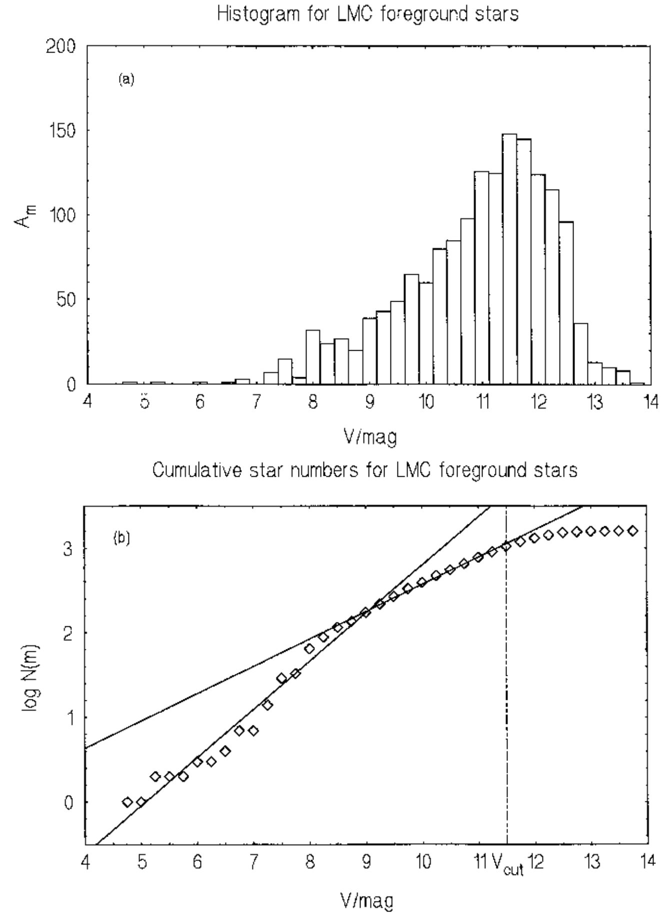

Fig. 1. a) Histogram of 1604 LMC foreground stars with high quality *UBV* photometries taken from Papers I and II, and the literature (see text). Plotted are absolute numbers, $A_{\rm m}$, per magnitude interval, $\Delta V = 0\overset{\rm m}{.}25$. **b)** Cumulative star numbers, $\log N(\rm m)$, as a function of V with the cut–off magnitude, $V_{\rm cut}$, and the slopes indicated (see text). The class interval is again $\Delta V = 0\overset{\rm m}{.}25$

3. Results

3.1. Photometric results and accuracies

The results of the photometries are arranged in two tables. Table 2 contains a supplement of *UBV* photometries of 545 galactic foreground stars in front of the LMC, which have been measured with the same accuracy as the data presented in Table 7 of Paper I. The criterion for the selection to this list demands at least two independent measurements of a star in different photometric nights, and a photometric accuracy corresponding to quality 2 for V and $B-V$ as defined by Nicolet (1978), i.e. errors smaller than $0\overset{\rm m}{.}06$.

In a second table (Table 3), all photometries of foreground stars are collected for which only one measurement exists, or the qualities for V or $B-V$ are 1 ($\sigma \geq 0\overset{\rm m}{.}06$). Despite their “bad photometries” (most of the stars were measured only once, but have small photometric errors), these 379 stars are published here, because no further photometric observations are planned. Two more stars (one in Table 2 and one in Table 3) turned out to be identical with stars already published in Paper I. Nevertheless, their additional photometries have been published here (cf. the remarks to the tables).

Contrary to Paper I, where the stars were ordered by FD–numbers (catalogues of Fehrenbach & Duflot 1970, 1973, and 1982), Tables 2 and 3 list the entries according to their HD/HDE numbers. Stars which do not appear in the HD/HDE catalogues, are given the designation of the catalogues they were taken from. These designations are listed subsequent to the HD/HDE entries in numerical and alphabetical order (Col. 2). Also included in both tables are those foreground stars which have been measured erroneously instead of others that should have been observed. These stars are listed under the designation of the catalogued star nearby and marked by an ending “F” (= false), e.g. “HDE 268841F” if HDE 268841 should have been measured. All 35 erroneous stars are identified in Fig. 3 on finding charts reproduced from the Southern Digitized Sky Survey (ESO–SERC).

Following, is a description of the columns of Tables 2 and 3:

Column 1: HD/HDE number
Column 2: other identifiers given in catalogues of LMC foreground and member stars, as well as in the Harvard Variable list: A = Ardeberg (1972); B = Brunet (1975); FD = Fehrenbach & Duflot (1970, 1973, and 1982); G = foreground stars erroneously identified as LMC members by Fehrenbach & Duflot (1970); GSC = HST Guide Star Catalogue; HV = Harvard Variable, Leavitt (1908); LH = Lucke & Hodge (1970), Lucke (1972); NS = Sanduleak (1969); RM = Rebeirot et al. (1983); RV = Feast et al. (1960); S = Fehrenbach & Duflot (1970); SP = Sanduleak & Philip (1977); STO = Stock et al. (1976); TRM = Reid et al. (1990); WOH = Westerlund et al. (1981); WOHg = Westerlund et al. (1981), LMC giants
Column 3: number of measurements
Columns 4-9: V, $B-V$, $U-B$, and mean errors
Columns 10-12: qualities refering to V, $B-V$, and $U-B$ respectively as defined by Nicolet (1978)
Column 13: an asterisk ($*$) indicates a remark at the end of the table, while a number refers to a finding chart number in Fig. 3.

All stars in Tables 2 and 3 which are listed (erroneously) as LMC members in the various catalogues (e.g. Sanduleak 1969; Stock et al. 1976; Westerlund et al. 1981) have been identified as foreground stars by means of their radial velocities, spectral classifications, their photometries in the present publication, and other references from the literature.

3.2. Statistics and color–color diagram

The histogram in Fig. 1a plots the star numbers, $A_{\rm m}$, as a function of V magnitudes for all stars with reliable photometries (as defined in Sect. 3.1), i.e. all stars from Paper I (Table 7) and Paper II (Table 2), together with 104 stars of equivalent qualities from the literature. The cut–off of the exponential increase in the star numbers, $A_{\rm m}$ (Fig. 1a), and the linear slope of the cumulative star numbers, $\log N({\rm m})$ (Fig. 1b), as a function of V, at $V_{\rm cut} = 11\overset{\rm m}{.}5 \pm 0\overset{\rm m}{.}2$ suggest that the sample can be taken as a statistically representative subsample of LMC galactic foreground stars for $V \leq V_{\rm cut}$ (cf. Paper I). In their different catalogues, Fehrenbach & Duflot selected the foreground stars by means of objective–prism radial–velocities, leaving out all those objects that showed overlapping spectra, especially in the crowded LMC bar. This makes the sample of photometries presented in Fig. 1 a magnitude limited subsample of all LMC galactic foreground stars. However, Fehrenbach & Duflot do not give any statements on the completeness of their selections. A detailed analysis carried out by Oestreicher & Schmidt–Kaler (1995) suggests that the limit of completeness for the G to M type stars which comprise the majority of the objects listed in Papers I and II is indeed given by an apparent V magnitude of about $11\overset{\rm m}{.}5$. For the fewer B to F type stars, the limit is even shifted to fainter magnitudes of $12\overset{\rm m}{.}5$ to $13\overset{\rm m}{.}5$.

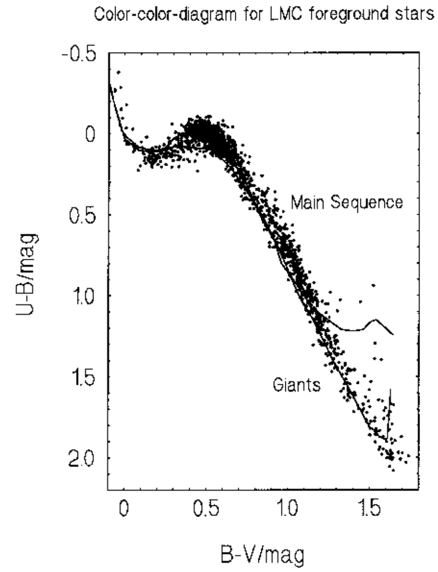

Fig. 2. Color–color diagram for the same stars as Fig. 1. The ZAMS and the respective line for the giants taken from Schmidt–Kaler () are plotted for comparison

The cumulative star numbers, for the representative sample ($V \leq 11\overset{\rm m}{.}5$) display a slope of (0.49 ± 0.02) mag^{-1} as a function of V which is compatible with the average all–sky value of 0.40 at $b = 30°$ (cf. Paper I). There is, however, a significant difference between the slopes for $4\overset{\rm m}{.}75 \leq V \leq 8\overset{\rm m}{.}5$ with ~ 0.57 mag^{-1} and $8\overset{\rm m}{.}5 \leq V \leq 11\overset{\rm m}{.}5$ with ~ 0.32 mag^{-1} which cannot be explained by an incomplete selection of stars, nor it is caused by the influence of interstellar extinction (dark clouds), as the galactic foreground reddening in the field is generally low ($E_{B-V} < 0\overset{\rm m}{.}15$; see below). Rather, the change of the slope points to different stellar populations in the galactic foreground (cf. Oestreicher & Schmidt–Kaler 1995).

Figure 2 presents a color–color diagram for the same 1604 stars as plotted in Fig. 1. Most of the stars belong to the main sequence and show only small to moderate reddenings. A detailed investigation by Oestreicher et al. (1995) gives $E_{B-V} = 0\overset{\rm m}{.}00$ to $0\overset{\rm m}{.}15$, and an average of $\bar{E}_{B-V} = 0\overset{\rm m}{.}06 \pm 0\overset{\rm m}{.}02$. Furthermore, a substantial number of K–type giants (luminosity class III) populate the lower right part of the diagram (cf. Paper I).

Acknowledgements. We gratefully acknowledge the Deutsche Forschungsgemeinschaft (DFG) for supporting the project under grants nos. Schm 160/39–1 and 2.

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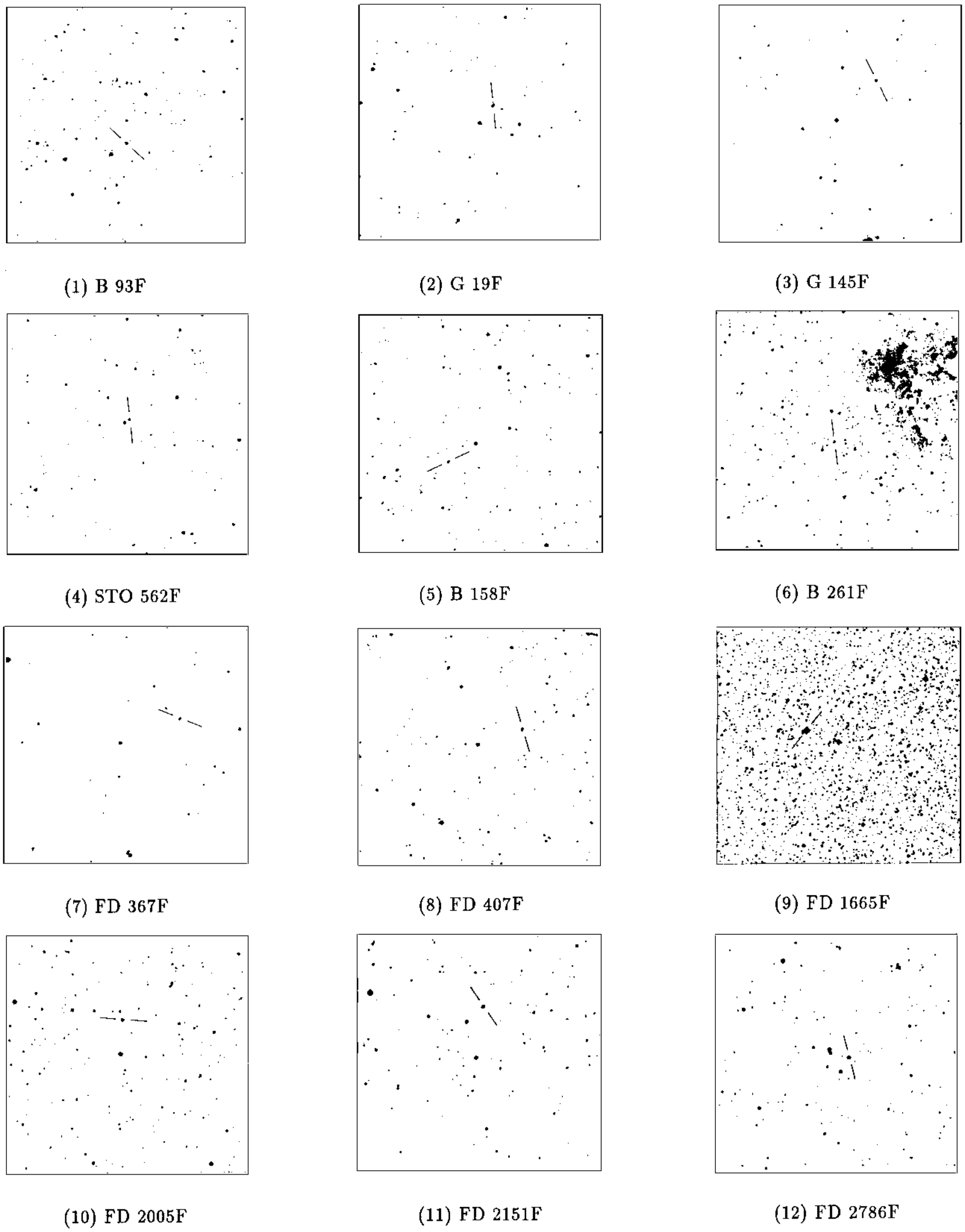
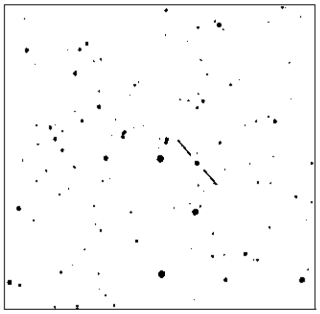
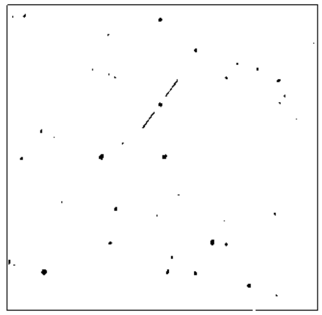


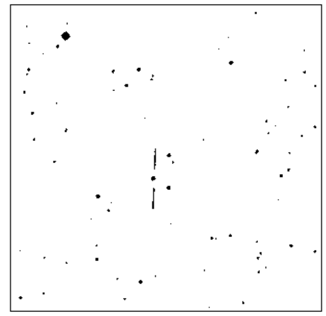
Fig. 3. Identification charts for all stars marked by a number in column "Remarks" in Tables 2 and 3. These numbers are given in brackets below each chart. All charts are reproduced as a gnomonic projection from the Digitized Sky Survey (ESO-SERC) with an effective passband between 400 and 550 nm. The field of view is a $8\farcm8 \times 8\farcm8$ square at a resolution of about $2''$. North is always up, East to the left



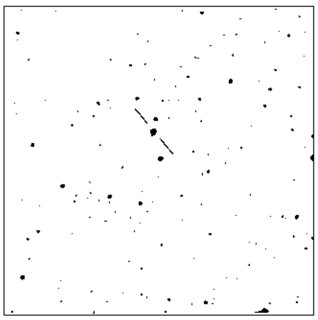
(13) FD 2809F



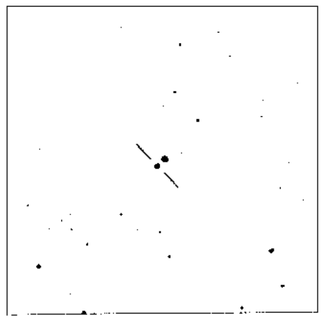
(14) G 116F



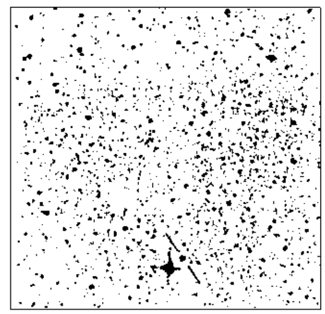
(15) G 166F



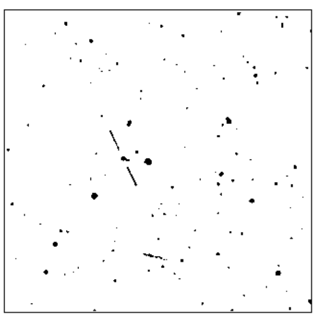
(16) G 231F



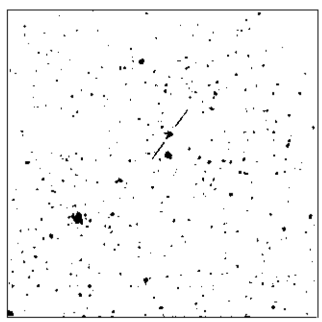
(17) HD 34871F



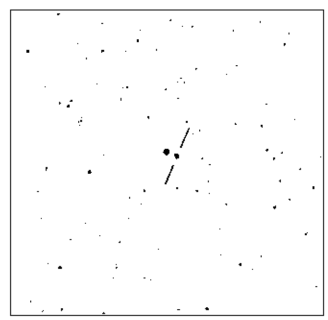
(18) HD 39475F



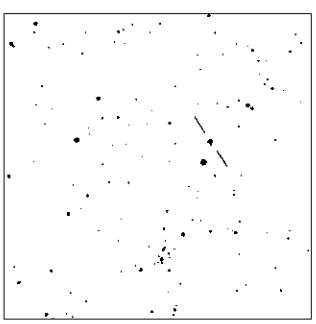
(19) HDE 268841F



(20) HDE 269421F



(21) HDE 269536F



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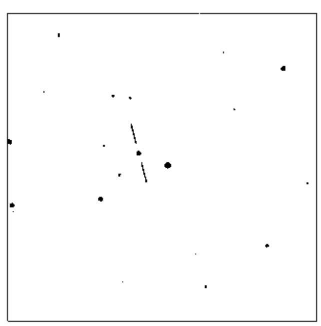
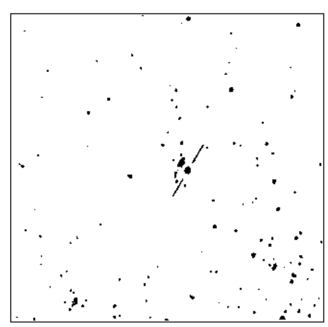
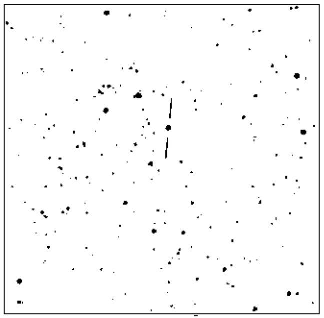


(23) HDE 270915F

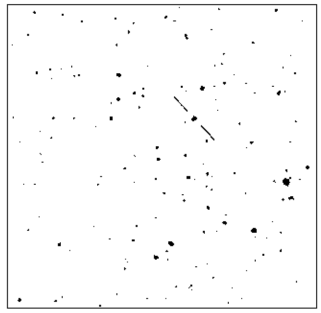


(24) NS 43 -66F

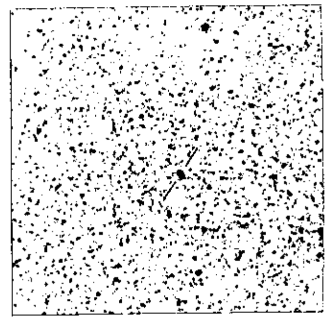
Fig. 3. continued



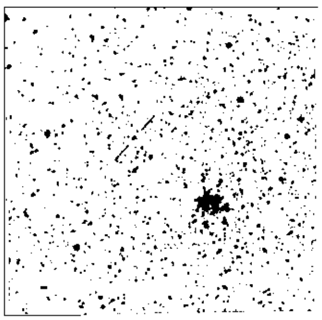
(25) RM 1-101F



(26) RM 1-199F



(27) RM 1-337F



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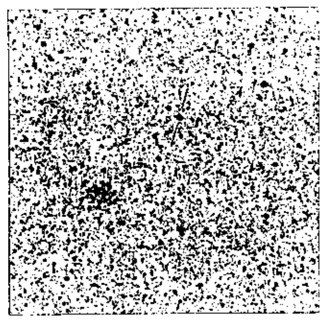

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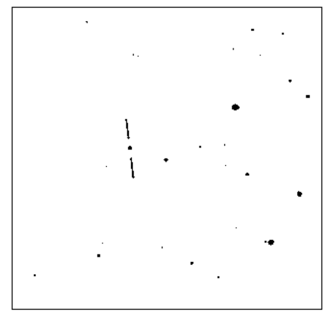

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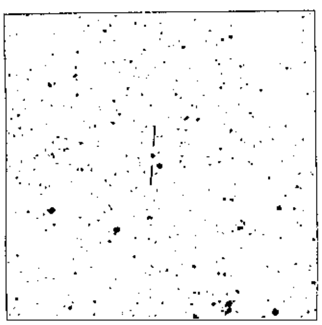
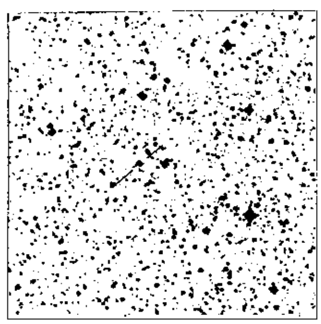
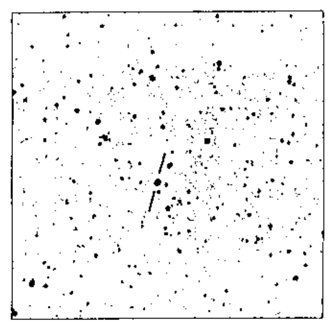


(31) S 52F



(32) STO 74F



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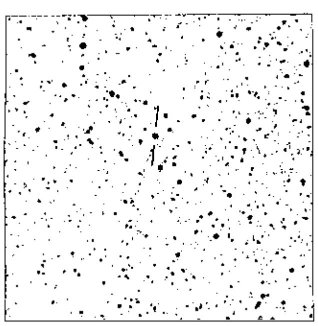

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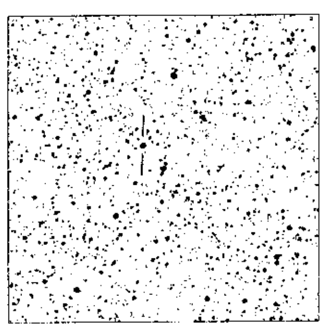

(35) STO 638F

Fig. 3. continued