COMMISSION No. 30

RADIAL VELOCITIES (VITESSES RADIALES)

Report of Meetings 1-10 August 1988

PRESIDENT: J. Andersen SECRETARY: B. Nordström

I. Business Meetings

Two business meetings were held, on August 1 (session 1) and August 9 (session 4). The following items were on the agenda:

I.1. MEMBERSHIP

The Commission voted to welcome the following new members of Commission 30, noting with particular satisfaction the improved representation of extragalactic research:

L.A.N. da Costa (Brazil)
M. Davis (USA)
A.P. Fairall (South Africa)
F.C. Fekel (USA)
C.B. Foltz (USA)
K.C. Freeman (Australia)
G.F. Gilmore (UK)
R. Giovanelli (USA)
L. Gouguenheim (France)
J.-L. Halbwachs (France)
P. Hewett (UK)
R.W. Hilditch (UK)
J. P. Huchra (USA)
H. Levato (Argentina)
B.M. Lewis (USA)
H. Lindgren (Sweden/ESO)
L.A. Marschall (USA)
R.D. Mathieu (USA)
T. Mazeh (Israel)
R.S. McMillan (USA)
J. Melnick (Chile/ESO)
G. Meylan (Switzerland/ESO)
R.C. Peterson (USA)
H. Quintana (Chile)
K. Ratnatunga (Sri Lanka)
R.P. Stefanik (USA)
G. Wegner (USA)

C.T. Bolton (Canada) has resigned in order to respect the three-Commission limit.

I.2. COMMISSION OFFICERS

The Commission voted to approve the following slate of Commission Officers for 1988-1991:

President: D.W. Latham Vice-President: G. Burki
Organizing Committee: J. Andersen, B. Campbell, L.A.N. da Costa, A. Florsch, K.C. Freeman, R.D. McClure, and L. Prévot.

I.3. COMMISSION NEWSLETTER

At its meeting in New Delhi in 1985, the Commission accepted with thanks the offer by the incoming OC member A. Florsch to edit and publish a Commission Newsletter to inform Commission members and others interested about programmes in progress and hence to encourage coordination and collaboration where desirable. Two issues of the Newsletter have appeared in the triennium. The Editor, A. Florsch, reported that, while there is considerable interest in receiving the Newsletter, it is not matched by a corresponding willingness to contribute to it; it appears impossible to get a sufficient number of articles for the Newsletter to continue as foreseen. The Commission, therefore, resolved to discontinue the Newsletter and expressed its warm appreciation to Dr. Florsch for his efforts as Editor of the Newsletter, and to Observatoire de Strasbourg for the generous financial support of its publication.

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I.4. WORKING GROUP (WG) ON RADIAL VELOCITY STANDARD STARS

As Chairman of the WG, J. Andersen presented a report on its activities, which included the conclusions of discussions of the WG held before the second business meeting. The report, which is reproduced below as Section III, concluded that while significant progress has been made in the past three years, it is still too early to propose a new set of IAU standard stars, and that work should continue at least until 1991.

The Commission approved the report and recommendations of the WG and expressed its thanks to the members, especially M. Mayor, R.D. McClure, and R.P. Stefanik, who have provided the largest amount of material on the standard stars in 1985-1988. The Commission reappointed the WG for the three-year period 1988-1991, with the following composition: J. Andersen (Chair), G. Burki, B. Campbell, D.W. Latham, M. Mayor, R.D. McClure, and R.P. Stefanik.

II. Scientific Meetings

Commission 30 held a total of six formal scientific sessions. Most of these were organized in collaboration with other Commissions, reflecting the impact of modern radial-velocity data on many fields of astronomy. The programmes of these meetings are summarized below or in the reports of the collaborating Commissions, as indicated. Moreover, members of Commission 30 made significant contributions to Joint Discussion II, "Formation and Evolution of Stars in Binary Systems"; these papers will be published in *Highlights of Astronomy, Vol.* 8 (1989, in press).

In addition, the following scientific contributions were presented at the end of the business meetings:

M. Barbier: Les Catalogues de Vitesses Radiales à l'Observatoire de Marseille (Poster).

D. Dravins: Spectral Line Asymmetries and Radial-Velocity Zero-Points.

F.C. Fekel: Radial-Velocity Observations of Close Visual Binary and Multiple Systems.

G. Isaak: Application of Optical Resonance Spectroscopy to High Precision Radial Velocity Measurements of the Sun and of Bright Stars: A Tribute to R.W. Wood of the Johns Hopkins University.

M. Mayor: Highlights of Recent Results from programmes with the CORAVELs.

R.P. Stefanik: Radial-Velocity Observing Techniques and Zero-Points with the CfA Echelle System at Oak Ridge Observatory.

II.1. RADIAL VELOCITIES OF HIGH PRECISION: STATUS AND VISTAS.

The meeting was organized and chaired by B. Campbell. It took place on August 4 (session 2), and attendance taxed the capacity of the room. The purpose of the meeting was to summarize the current status of the various operational techniques for precise radial-velocity determinations, point out the main features of what has been learned so far, and discuss directions for the future. Discussion was very lively and showed that several systems now in routine operation are reaching precisions of the order of ± 10 m s^{-1} and - equally importantly - give consistent results between the groups. It also became clear that all K giants observed, with Arcturus as the prime example, are variable at the ± 100-200 m s^{-1} level and with a variety of periods ranging from several hours to several months. Hence, the question of the general suitability of K giants as radial-velocity standard stars to the level of precision required in the future needs serious reconsideration.

The following scientific contributions were presented:

Alan W. Irwin: Long Period Radial Velocity Variations of Arcturus.

W.D. Cochran and A.P. Hatzes: The McDonald Observatory High Precision Radial Velocity Survey.

Robert S. McMillan: Accurate Radial Velocity Studies of K Giants and Solar-Type Stars.

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Geoffrey W. Marcy: Precise Radial Velocities with an Absorption Cell and an Echelle Spectrograph.
Myron A. Smith: Precision Radial Velocities in Arcturus: One More Round.
Bruce Campbell: Precision Radial Velocities: And Now For Some Astrophysics.

II.2. GALAXY REDSHIFT DETERMINATIONS: BETTER TECHNIQUES, BETTER STANDARDS.

This joint meeting between Commissions 28 (*Galaxies*) and 30 took place on August 8 (sessions 3 and 4). It was also the scientific meeting of the "Working Group on Redshift Determinations" of Commission 28 and was organized by the Chairman of the WG, J.P. Huchra, on behalf of both Commissions. J.P. Huchra also served as Chairman of the session. A main purpose of the meeting was to discuss the accuracy of current techniques for redshift determinations and the consistency of the zero-points between determinations in the radio and optical regions, and in the latter case, between emission- and absorption-line redshifts. The possible adoption of a set of standard redshift galaxies, in analogy with the well-known radial-velocity standard stars utilized in stellar work, was considered in some detail. The full programme for the meeting will appear in the report of IAU Commission 28 in this volume.

II.3. KINEMATICS OF GALACTIC POPULATIONS.

This joint meeting between Commissions 33 (*Structure and Dynamics of the Galactic System*) and 30 was held on August 9 (sessions 1 and 2). It was organized on behalf of both Commissions by J. Andersen, in collaboration with B.W. Carney, K.C. Freeman, and G.F. Gilmore; J. Andersen also served as Chairman of the meeting. Its purpose was to review the intense ongoing activity in the field, try to identify areas of consensus or controversy, and hence to point to directions for the future. Although several colleagues were, regretfully, unable to attend, the programme was nevertheless a very full one. The impressive contributions of new and exciting work by several young astronomers were especially gratifying, and the large attendance and very lively discussion gave a vivid impression of a field which is indeed dynamic in more than one sense.

The scientific programme was the following:

Session 1: The Galactic Halo and Bulge.

B.W. Carney: Introduction.
T. Armandroff: Kinematics of Disk and Halo Populations of Globular Clusters and Comparison with Field Stars.
R.M. Rich: Abundances and Kinematics of K Giants in the Nuclear Bulge of our Galaxy.
A. Spaenhauer, B.F. Jones, A. Whitford, and D.M. Terndrup: Kinematics of Bulge Giants from Proper Motions.
K. Yoss: Early G Giants in the Galactic Halo.
B.W. Carney and D.W. Latham: Results from the Proper-Motion Survey.
K. Ratnatunga: Kinematic Modeling of the Stellar Components.
J. Norris and K.C. Freeman: Rotation vs. [Fe/H] for Halo Stars.
R.C. Peterson and D.W. Latham: Pal 15 and the Mass of the Outer Galaxy.

Session 2: The Thin and Thick Disks.

R. Wielen: Introduction: On Thin Disks and Flat Halos in Galaxies.
L. Blitz: Rotation of the Outer Disk.
J. Lewis: Kinematics and Chemical Properties of the Old Disk of the Galaxy.
K.C. Freeman: Kinematics of the Thick Disk and Halo.
J. Norris and E.M. Green: The Transition from Halo to Thin Disk.
C. Flynn: Kinematics in a Galactic Rotation Field.
E. Friel: Kinematics of Old Open Clusters and the Old Disk Field.
J. Laird, D.W. Latham and B.W. Carney: Evidence for a Thick Disk Population in a Proper Motion Sample.
J. Andersen and B. Nordström: Progress Report on a Kinematically Unbiased Sample of Dwarf F Stars.

II.4. THE BAADE-WESSELINK METHOD: RECENT ACHIEVEMENTS AND FUTURE GOALS.

The meeting was organized on behalf of Commissions 27 (*Variable Stars*) and 30 by G. Burki (chair), T.G. Barnes III, and B.W. Carney. It was held on August 9 (session 3), chaired by G. Burki. Its purpose was to review the recent upsurge in both the quantity and quality of B-W analyses for RR Lyraes, Cepheids, and other types of pulsating stars. This is due primarily to the systematic application of modern techniques for precise radial-velocity determinations for faint stars, but also to improvements in the theoretical tools for the analysis. In order to highlight the status of the latter, the organizers had made efforts to have several different groups analyze the same set of observations for a given star (W Sgr). Discussion in the standing-room-only audience was quite vigorous and no doubt boded well for the success of IAU Colloquium No. 111 ("The Use of Pulsating Stars in Fundamental Problems of Astronomy"), which took place the week after the General Assembly. The full programme of the meeting will be published in the report of IAU Commission 27 in this volume.

II.5. SCIENTIFIC REPORT OF THE IAU WORKING GROUP ON STANDARD STARS.

The Working Group on Standard Stars is established by Commission 45 (*Stellar Classification*), with Commissions 29 (*Stellar Spectra*) and 30 as co-sponsors (not to be confused with the Working Group on Radial-Velocity Standard Stars of Commission 30 itself). Its meeting, on August 10 (sessions 1 and 2), was organized and chaired by the Chairman of the WG, A.H. Batten.

On behalf of Commission 30, J. Andersen gave a summary of the work on radial-velocity standard stars which is reported in Section III below. The full programme of the meeting appears in the report of IAU Commission 45 elsewhere in this volume.

II.6. PROGRESS IN THE UNDERSTANDING OF THE DYNAMICS OF STAR CLUSTERS.

This joint meeting of Commissions 37 (*Star Clusters and Associations*) and 30 was organized on behalf of both Commissions by C.P. Pryor, and took place on August 10 (sessions 3 and 4). Its purpose was to promote cooperation between theorists and observers, formulated in the questions: "What observations are needed to check recent theoretical results?", and "What theoretical work is needed to interpret the new observations?". In order to allow an in-depth discussion, the subject was deliberately limited to globular clusters only, which have also seen the most intense recent theoretical and observational activity. In the same spirit, the programme was concentrated on a few, thorough reviews with ample time for discussion. The meeting attracted a large and interested audience, with front-line research well represented on both sides of the podium, and the lively debate showed that the stated goal of the meeting had been attained very successfully.

The scientific programme of the meeting was the following:

Session 1: Theory (Chair: C.P. Pryor).

D.C. Heggie: Core Collapse and Equipartition.
J.P. Ostriker: Binary Stars and the Evolution of Globular Clusters.
S.M. Fall: Rotation of Globular Clusters.

Session 2: Observations and General Discussion (Chair: I.R. King).

C.P. Pryor: Mass Functions, Velocity Anisotropy, and Binary Stars in Globular Clusters.
G. Meylan: Rotation of Globular Clusters.
P. Seitzer: Radial Velocity Observations of Cusp Clusters.
General Discussion.

III. Report of the Working Group on Radial-Velocity Standard Stars

SUMMARY

Recently, low-amplitude (~500 m s^{-1}) orbital motions have been shown to exist among solar-type dwarfs, presumably due to low-mass companions. Also, more irregular variations of somewhat smaller amplitude appear to be ubiquitous among late-

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type giants. As a consequence, no new set of primary radial-velocity standard stars can be proposed at this time, but observations will continue with the aim of reaching definite recommendations in 1991. About 300 observations of asteroids indicate that the absolute zero-points of the three main systems (CORAVEL, CfA, and DAO), and hence of the new standard system, will eventually be established to ±100 m s^{-1} or so. Recommendations for stars to be monitored 1988-1991 are made (Table I).

III.1. INTRODUCTION

By 1984, it had become apparent that the system of radial-velocity standard stars adopted by the IAU in 1955 was rapidly becoming obsolete and would be unable to fulfill its intended purpose in a future dominated by new instruments capable of yielding accuracies in the range 100-500 m s^{-1}, even on very faint stars. The issue was discussed during IAU Colloquium No. 88 (*Stellar Radial Velocities*, Ed. A.G.D. Philip and D.W. Latham, L. Davis Press, Schenectady, N.Y., 1985; referred to below as C88), see in particular the contributions by Batten (p. 325) and Mayor and Maurice (p. 299). It was agreed that a new system of standard stars was needed, in which both the velocities of individual stars and the absolute zero-point of the system were known to about ±100 m s^{-1}. At its meeting in New Delhi in 1985, Commission 30 appointed a Working Group (WG) with the task of examining the existing IAU system of radial-velocity standard stars, organizing such observations as were deemed necessary to select candidates for a new system, and presenting a preliminary list of stars to the Commission at its meeting in Baltimore in 1988 (*Trans. IAU. Vol.* XIXB, p. 237, 1986). The following have served on the WG in 1985-1988: J. Andersen (Chair), W.I. Beavers, B. Campbell, D.W. Latham, M. Mayor, R.D. McClure, and R.P Stefanik.

An account of the strategy for the selection of new radial-velocity standard stars and of the observational work carried out until November, 1987, is given in the triennial report of Commission 30 for the years 1984-1987 (*Trans. IAU. Vol.* XXA, p. 362, 1988) and will not be repeated here. The following report summarizes results and developments over the past year, the results obtained in discussions within the WG in Baltimore, and the recommendations of the WG for the future directions of the work.

III.2. INDIVIDUAL STANDARD STARS

Already Batten et al. (Publ. Dominion Astrophys. Obs. 16, p. 143, 1983) and Mayor and Maurice (C88, p. 299) identified a number of current IAU standard stars with definitely variable velocities and/or with mean velocities differing appreciably from the nominal values. In order to select future standard stars with the longest possible history of precise observations without detected variability, it was decided to base the search on those 25 stars listed by Mayor and Maurice (their Table VI) which had $|\delta|<20°$, so that all future standards would be observable from both hemispheres. These stars are listed in Table I below, and intensive observations of these stars during the period 1985-1988 were recommended. Many observations have been made, so that the material available for discussion now includes about 1000 observations of a smaller number (~12) of standards with the Center for Astrophysics (CfA) echelle system at Oak Ridge Observatory (Latham, C88, p. 21), about 2500 observations of a much larger sample (including stars south of those in Table I) from CORAVEL II at ESO in Chile (Mayor, C88, p. 35), and about 600 observations of ~35 stars from Victoria, mostly from the DAO scanner (McClure et al., C88, p. 49), but also some 2.4 Å mm^{-1} photographic observations by A.H. Batten.

There is not yet a large and homogeneous overlap of well-observed stars between these lists, but there are clear suspicions that some of them are variable at the level of ~500 m s^{-1} and with periods from a few months to years. The confirmed cases of the giant HR 152 (McClure et al., Publ. Astron. Soc. Pacific 97, p. 740, 1985) and the dwarf HD 114762 (Latham, paper at Joint Discussion II, *Highlights of Astronomy, Vol.* 8, 1989, in press), with a period of only 84 days and a 500 m s^{-1} amplitude are probably just the tip of an iceberg of yet unknown dimensions.

Continued close scrutiny is clearly needed before any of the stars can be declared constant at a level of ±100 m s^{-1}. Concerning the giant stars - the majority of the present standards (!) - the available data of high precision (±10 m s^{-1}) indicate that most or all late-type giants vary by ±100 m s^{-1} or more with a range of periods (see II.1 above) and may not at all, therefore, be suitable as standards at the desired level of precision. More dwarf candidate stars are evidently desirable, and several exist which have now been monitored for about a decade with the requisite precision. These will be added to the list in Table I and monitored over the next three years with the best possible precision. It would clearly be premature to make definite selections for a new system of radial-velocity standard stars at the present time.

III.3. ZERO-POINTS

One conclusion by Mayor and Maurice (C88, p. 299) was that the zero-points of the previous lists of "bright" ($V < 4.3$) and "faint" ($V > 4.3$) IAU standards differed by about 800 m s^{-1}. A key element in the programme of the WG was the observation of asteroids, which present starlike images, and the velocities of which can be computed to ±10 m s^{-1} or better. About 200 such observations have been made at CfA, about 35 with CORAVEL, and a similar number at DAO. In addition, sky exposures are taken frequently at both CfA and DAO. These data show that the CfA and DAO instrumental zero-points are within about 100 m s^{-1} of that defined by the asteroids, while a preliminary correction of about +400 m s^{-1} is indicated for CORAVEL. This again indicates that the absolute (asteroid) zero-point is roughly midway between those of the "bright" and "faint" IAU lists. Comparison of the observations of the standard stars (dwarfs and giants) after application of these zero-point corrections would then be expected to show agreement between all three systems.

In fact, excellent agreement is found between CORAVEL and DAO, but a significant mean difference of about 400 m s^{-1} surprisingly appears between those and the CfA velocities. Closer examination of the data shows that agreement is, in fact, obtained for the (only four) dwarfs in common, while the discrepancy for the giants alone is some 500 m s^{-1}, larger for later spectral types and/or higher luminosity. Hence, the asteroid zero-point correction is satisfactory for the (solar-type) dwarf stars, but not for the (later-type) giants. This is most likely due to a mismatch between the line spectra of the giants and that of the solar (or sky) template spectrum used in the cross-correlation, an effect which cancels out much less accurately in the 50-Å spectral range of the CfA echelle than in the 1000-1500 Å ranges covered by the two other instruments. Further studies by means of synthetic solar-type and giant spectra in the relevant range, and by observations of objects (clusters, visual binaries) containing both types of star, will be necessary in order to demonstrate the validity of this hypothesis. In order to help consolidate the comparisons between the major systems, several stars with long observational histories in at least two of these systems have been added to the list of stars to be monitored carefully over the next three years (Table I). However, prospects appear good that, eventually, the three independent, zero-points can be shown to be consistent to well within the desired ±100 m s^{-1}. The material on asteroids already appears to be about adequate to establish an absolute zero-point for the common system to that precision.

III.4. HIGH-PRECISION STANDARDS OF RELATIVE RADIAL VELOCITY

The only instrument for high-precision radial-velocity observations which has been in routine production for several years is that of the Canadian group (Campbell et al., Astrophys. J. 331, 902, 1988). While their results indicate that some dwarf stars may have constant radial velocities to within their precision of ±15 m s^{-1}, independent confirmation by at least one other group would be required before a set of standards of relative radial velocity could be proposed. An even longer span of observations of each candidate star is also desirable. As several other groups have now reached the stage of routine production of radial velocities of this kind of precision, the situation may be better in three years.

III.5. SECONDARY STANDARDS

The WG has considered the possible need for secondary standards, especially for work on faint stars with large telescopes and with detectors of limited dynamic range. It was agreed that, once a satisfactory system of primary radial-velocity standard stars has been established, secondary or regional standards can be easily established in each case, close to the faint-star targets, with one of the existing systems. Therefore, the WG does not at this time recommend that the IAU establish a system of secondary standards.

III.6. EARLY-TYPE STANDARDS

No satisfactory set of radial-velocity standard stars exists for early-type stars; the few existing candidates are inadequate with respect to both the evidence on their constancy, the accuracy of the velocity zero-point, and the coverage of spectral types (O-B-A), luminosity classes, and - especially - rotations. Better techniques for precise radial-velocity determination for such stars are needed and are being developed; once the necessary precision has been demonstrated, what will be needed is a set of early-type stars (visual binaries, clusters) with known and constant velocities. The selection of such stars, and the observation of solar-type calibration objects, can begin already now and are strongly encouraged.

III.7. CONCLUSIONS AND RECOMMENDATIONS

The main conclusions and recommendations of the WG may be summarized as follows:

1. As more time is needed to establish the constancy (or eventually determine the orbits!) of the candidates for new primary standards, no definitive list can be proposed at this time. In order to avoid confusion caused by intermediate systems, improved, but still preliminary velocity data will also not be given; the previous IAU system remains in force. As an interim measure, it will be proposed to the *Astronomical Almanac* that those standard stars found to vary by several km s^{-1} be omitted from future editions of the *Almanac*.

2. Meanwhile, observations should continue, with the highest possible accuracy, of the stars in Table I below, and of additional late-type dwarfs to be selected shortly by the WG. These should continue until 1991, with a view to establishing a definitive set of new primary standards, accurate to ± 100 m s^{-1}, by then. Any observers able and willing to contribute radial-velocity observations of precision in the range 100-500 m s^{-1} are urged to make such observations of the stars in Table I and contact the Chairman or any other member of the WG so that these data may be incorporated in the new system.

3. A few more minor planet observations are needed, mostly to base the zero-point on a somewhat larger number of asteroids. It appears probable that the absolute zero-point of the new standard velocity system can be secured to $\leq \pm 100$ m s^{-1}.

4. Establishing a satsifactory system of standard stars of early spectral types (O-B-A) will take several years of effort. However, preparatory work such as development of observational techniques, and selection and observation of suitable calibration objects, can be initiated now and is strongly encouraged.

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TABLE I. List of future primary standard star candidates, and other important reference stars, to be intensively observed in 1988-1991. RV_{IAU} is given in km s^{-1}.

HD No.	Name	α (2000.0)	δ	V	Sp. type	RV_{IAU}
IAU primary standard star candidates:						
693	6 Cet	$00^h11^m15^s.8$	-15°28'05"	4.89	F6 V	+14.7
4128	β Cet	00 43 35.3	-17 59 12	2.04	K0 III	+13.1
8779		01 26 27.2	-00 23 55	6.41	K0 IV	-5.0
18884	α Cet	03 02 16.7	+04 05 23	2.53	M1.5 III	-25.8
22484	10 Tau	03 36 52.3	+00 24 06	4.28	F9 V	+27.9
26162	43 Tau	04 09 09.9	+19 36 33	5.50	K2 III	+23.9
29139	α Tau	04 35 55.2	+16 30 33	0.85	K5 III	+54.1
36079	β Lep	05 28 14.7	-20 45 34	2.84	G5 II	-13.5
66141		08 02 15.9	+02 20 04	4.39	K2 III	+70.9
81797	α Hya	09 27 35.2	-08 39 31	1.98	K3 II-III	-4.4
89449	40 Leo	10 19 44.1	+19 28 15	4.79	F6 IV	+6.5
92588	33 Sex	10 41 24.1	-01 44 29	6.26	K1 IV	+42.8
107328	16 Vir	12 20 20.9	+03 18 45	4.96	K0 III	+35.7
114762		13 12 20.5	+17 31 01	7.31	F7 V	+49.9
124897	α Boo	14 15 39.6	+19 10 57	-0.04	K1 III	-5.3
136202	5 Ser	15 19 18.7	+01 45 55	5.06	F8 IV-V	+53.5
146051	δ Oph	16 14 20.6	-03 41 40	2.74	M0.5 III	-19.8
161096	β Oph	17 43 28.3	+04 34 02	2.77	K2 III	-12.0
171391		18 35 02.3	-10 58 38	5.14	G8 III	+6.9
182572	31 Aql	19 24 58.1	+11 56 40	5.16	G8 IV	-100.5
187691	o Aql	19 51 01.5	+10 24 56	5.11	F8 V	+0.1
203638	33 Cap	21 24 09.6	-20 51 07	5.77	K0 III	+21.9
204867	β Aqr	21 31 33.4	-05 34 16	2.91	G0 Ib	+6.7
212943	35 Peg	22 27 51.5	+04 41 44	4.79	K0 III	+54.3
213014		22 28 11.4	+17 15 48	7.70	G8 III	-39.7
Other reference stars:						
28099		04 26 39.7	+16 44 50	8.10	G0 V	+39.6
54716	63 Aur	07 11 39.3	+39 19 14	4.90	K4 III	-27.1
	M67-978	08 51 17.4	+11 45 24	9.72	K4: III	+34.7
103095		11 52 58.7	+37 43 08	6.45	G8 Vp	-99.1
113996	41 Com	13 07 10.6	+27 37 29	4.80	K5 III	-14.7
176670	λ Lyr	19 00 00.8	+32 08 44	1.47	K2.5 III	-16.9

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