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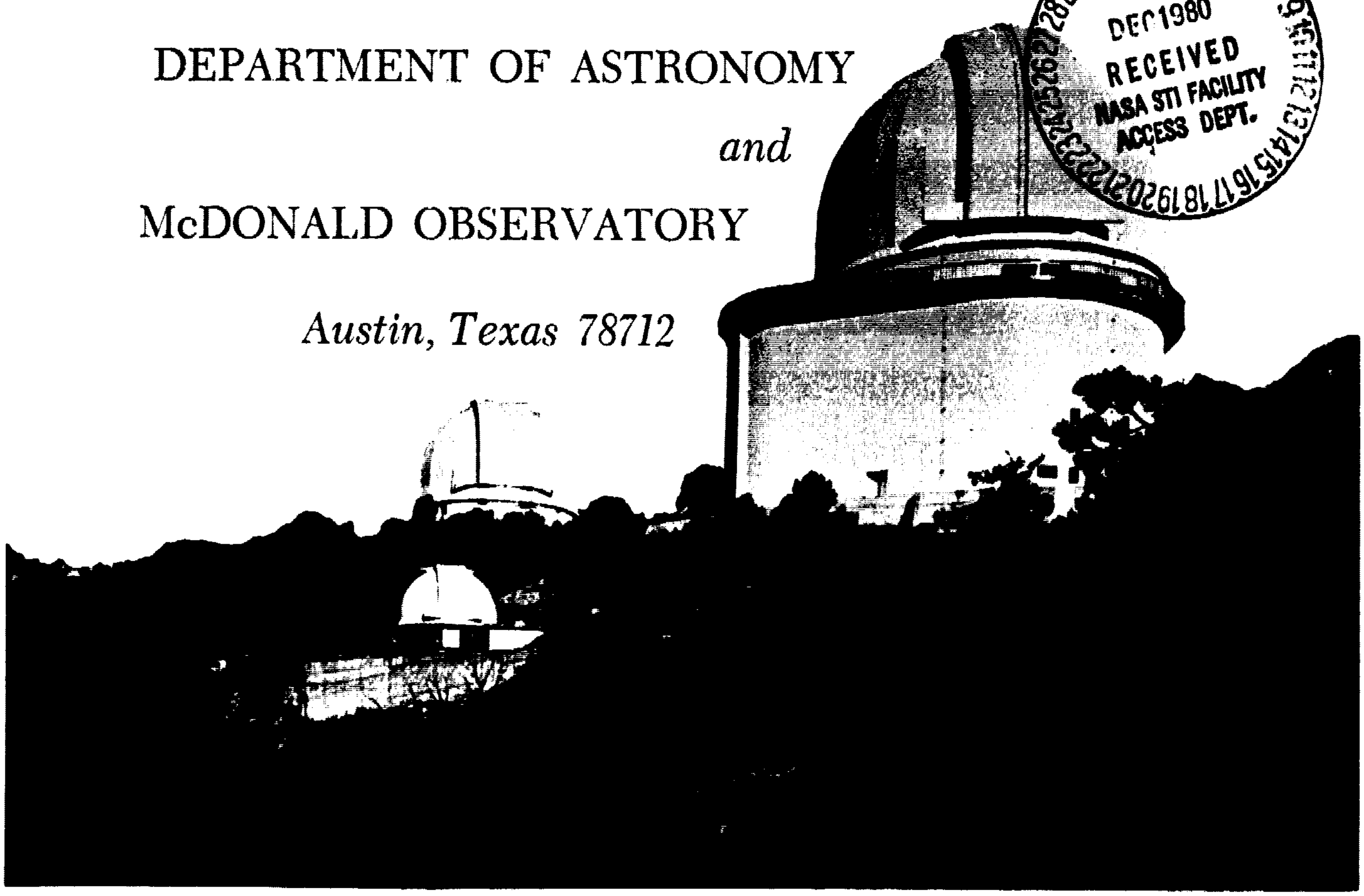

PHOTOMETRY, SPECTROPHOTOMETRY AND POLARIMETRY OF COMET P/ENCKE DURING FALL OF 1979

Report No. 1

FINAL REPORT under JPL Contract BP-708823

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ABSTRACT

Broadband S-20, B and V magnitudes of P/Encke were obtained with the digital area photometer, using an IDS detector on the 2.7 m telescope at McDonald Observatory during August 1979. The area photometer samples a 38 x 38 arcsec field with 0.6 arcsec pixels and typically reaches a sky background of $21^{m}.6$/pixel in V in five minutes. The transformation of S-20 to V was $1^{m}.79 \pm .10$. The notation V(S-20) will be used for S-20 magnitudes transformed to V magnitudes.

The observed mean V(S20) magnitudes for 21, 22, 24 and 26 August were 18.25±07, 19.54±20, 19.39±09 and 19.13±35 respectively. If the mean activity level is 19.35 for this time period, then an outburst of 1.1 magnitudes occurred on or before 21 August. The variation in the V(S20) magnitudes (26, 5-minute integrations) on the best photometric night (21 August) is small and random indicating either a lack of rotational albedo variations or, more likely, a masking of the nucleus by the outburst activity. The difficulty of doing photometry on a 19th magnitude moving object is emphasized by the loss of a significant portion of two nights due to near occultations with 18th magnitude stars.

The disagreement between the observed (19.35) and the predicted value (20.05) for the nuclear magnitude may be significant, but the mean level may still be affected by the 21 August outburst. The (B-V) color appears to be bluer during outburst (0.3 versus 0.8).

A spectrum covering the region from 3630 to 4900 Å at a resolution of 5 Å was obtained on 27 August with the IDS spectrograph. The spectrum was featureless, showing no emission at the CN or CO^+ wavelengths. Averaging the flux into 100 Å bins resulted in a spectrum with a S/N of 2 which is insufficient to determine the reflectivity of P/Encke near aphelion.

Attempts to measure the polarization of P/Encke on 19 September 1979 when it was at 3.9 AU and a phase angle of 7° were unsuccessful.

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Introduction

The prime objectives of the Comet P/Encke project were to measure the rotation period and to determine the nature of the reflection spectrum of the bare nucleus when P/Encke was just past perihelion and in the range of 3.9 to 3.7 AU from the sun. This effort and final report are similar to that for P/Tempel-2 completed by Barker and Smith (1980). The Digital Area Photometer (DAP) mounted at a Nasmyth Cassegrain position on the 2.7 m telescope was used to monitor the brightness fluctuations of the 19th magnitude comet on a five-minute time scale. As with P/Tempel-2, the determination of a rotation period of the bare nucleus was hampered by an outburst of cometary activity on the first night of the initial observing run. The assumption that comets are quiescent at large heliocentric distances is proving to be erroneous.

The determination of the reflection spectrum of the bare nucleus was to provide a zero point for cometary activity (particularly molecular emission) on P/Encke near aphelion. The completion of an improved blue sensitive Image Dissector Scanner (IDS) tube during the initial observing session helped in attempting to reach this goal. However, the only result that can be reported is that we did detect a positive signal but with insufficient S/N to provide any interpretation about the composition of the nucleus from its reflection spectrum. The other prime objective, the determination of the rotation period from DAP photometry, did take priority on the photometric nights during the first part of the 10-day August observing session. When the new blue detector was put into successful operation, spectrophotometric observations took priority at the end of the observing run and during the remainder of the scheduled 2.7 m telescope time. Poor weather conditions prevented comet observations during subsequent observing runs in September (fog) and November (seeing > 4 arcsec).

Unfortunately, TV acquisition and guidance were not available on the Breger Polarimeter. Telescope time was concurrently scheduled in September and October on both the 2.1 and 2.7 m telescopes in order to provide P/Encke offsets from nearby stars using the TV system on the 2.7 m telescope. We could not detect P/Encke above sky background on September 19 with the polarimeter on the 2.1 m telescope even with good offsets provided from the 2.7 m TV acquisition system.

In the following technical discussion sections the photometry, spectroscopy and polarimetry will be discussed separately, although most of the observations were interleaved on a daily basis depending on the weather conditions each afternoon.

Technical Discussion — Observational Schedules

To meet the goals in the statement of work, observing time was requested on the 2.7 m Cassegrain systems (DAP - Digital Area Photometer, and IDS - Image Dissector Scanner) and on the Digicon spectrograph at the 2.1 m Cassegrain focus for dark time during August, September and November. Before the scheduled November Digicon run it was apparent that the new Digicon detector would not be available due to production delays with its manufacture at Electronic Vision Corp. An agreement was reached with the 2.7 m IDS observers (B. and D. Wills) that during their scheduled November IDS run the P/Encke project would be given priority during the telescope time P/Encke was available until a good spectrum was obtained. Unfortunately, non-excellent (seeing greater than 1 - 2 arc-second and photometric) observing conditions prevented even the detection of the 20th magnitude comet during the November 2.7 m IDS run.

The new Breger Polarimeter was scheduled for two seven-day runs during September and October (2.1 m) with the understanding that P/Encke observations would be made on nights when excellent seeing (1 arcsec) and transparency (photometric) conditions prevailed and the comet could be acquired initially with the 2.7 m TV system. Under excellent conditions on September 19 Dr. M. Breger failed to detect the comet. No observations were attempted during the October run due to the intrinsic faintness of P/Encke ($\sim 20^{m}.2$) at that time and the failure to detect it when it was 19.8 under excellent conditions.

Observational Log — Spectral — Photometric

UT Date (1979)	Inst.	Sky	Seeing	Objects
18 Aug	IDSR	Cloudy	6"	Comet Meier
19 Aug	IDSR	Cloudy	---	None
20 Aug	IDSR	PC	3	P/Encke near POSSE limit, P/VanB BD°+25
21 Aug	DAP	Clr	1.5-2.0	SA82, Aquila, SA71, P/Encke
22 Aug	DAP	Clr	1.5-2.5	SA71, N7078, P/Encke
23 Aug	IDSB	Clr-PC	6-2	P/Encke too near bright star, P/VanB, NYSA BD+25, BD+40
24 Aug	DAP	Clr	2.4-3.5	N7078, Nova Cygni, P/Encke
25 Aug	DAP	Cloudy	---	None
26 Aug	DAP	Clr	1.5-4	SA82, N7078, SA71, P/Encke
27 Aug	IDSB	Clr	3+	Feige 110, P/Encke, NYSA

UT Date (1979)	Inst.	Sky	Seeing	Objects
14 Sep	DAP/ IDSB	Fog	---	None
15 Sep	DAP/ IDSB	Fog	---	None
16 Sep	DAP/ IDSB	Fog	---	None
19 Sep	TV/ Polar	Clr	1	Attempt to offset from 2.7 m TV
17 Nov	IDSB	Clr	2-3	No object at POSSE limit
18 Nov	IDSB	Clr	4^{π}	No attempt
19 Nov	IDSB	Cloudy	3^{π}	No attempt
20 Nov	IDSB	Clr	$>5^{\pi}$	No attempt
21 Nov	IDSB	Clr	$>5^{\pi}$	No object at POSSE limit
22 Nov	IDSB	Clr	3^{π}	No object at POSSE limit

Definitions and Abbreviations:

DAP	Digital Area Photometer
IDSB or IDSR	Image Dissector Scanner, Blue or Red detector
Polar	Breger Polarimeter
SAXX	DAP Standards from Purgathofer Standard Areas
N7078	DAP Standards from Sandage
Feige 110	Stone Spectral Standard
BD+25°3941	Stone Spectral Standard
BD+40°4032	Stone Spectral Standard
VanB	Comet P/Van Biesbrock
NYSA	MP 44 NYSA for Solar Spectrum
POSSE	Palomar Sky Survey E Plates

Before P/Encke and various standard stars were available during the August and September runs, the early evening 2.7 m Cassegrain time was shared with extragalactic observers M. McCall and P. Rybski. In return, M. McCall relinquished part of his September time to provide TV offsets for the 2.1 m for the polarimetry program. In November, after attempts were made to locate P/Encke during the early evening, the observing time was relinquished to extragalactic observers B. and D. Wills.

The SEC Vidicon system operated flawlessly at the 2.7 m Cassegrain focus for the IDS and DAP. The proposed modifications to flatten the response function of the TV guidance system were carried out just prior to the 10-day August observing run. The system significantly improved the field identification necessary to locate an object near the limit of the POSSE Charts. In fact when the weather conditions were good, the TV system detected objects below the POSSE Chart limits (~21 magnitude). Because of the non-availability of the 2.1 m Cass Digicon, its TV system was not checked out on the telescope although the system has been constructed.

Technical Discussion — Digital Area Photometry

The Digital Area Photometer (DAP) was used in the "20" aperture mode which projected a 38 by 38 arcsec field onto an Image Dissector Scanner. The phosphor was sampled with 0.6 arcsec pixels resulting in a 64 x 64 pixel digital frame. An entire frame is readout and stored with a cycle time of 0.285 seconds. All integrations were 100 frames (28.5 seconds) long with each integration being stored on magnetic tape. The six (100-frame) integrations were coadded to produce a 600 frame picture. Observations of the comet in the B and V filters and with no filter or the S-20 response of the IDS photocathode consisted of 600 frame pictures or an integration time of 2.85 minutes. 200 frame integrations were used for observations of the standard stars in the S-20 bandpass. A more complete instrument description is given by Rybski (1980). The (S/N) in the comet S-20 frames was sufficient to measure the comet brightness at about five-minute intervals with dark frames before each 600 frame observation. The comet was acquired using a SEC Vidicon system which can reach sky background (21 - 22) with a 4 - 6 second integration on a 4 x 5 arc min field The 2.7 m telescope track rates were adjusted to track the comet with stellar rates being used for standard or reference star integrations.

The DAP data reduction was carried out in Austin on the Astronomy Department's NOVA 1200 Digital Data Editor system which allowed us to numerically integrate the intensity above background within various sizes and shapes of apertures. The background level in a picture was fit with a plane surface to remove any systematic slopes in the background level after each picture had been flat fielded using flat fields obtained during the observation period. Residual background effects were negligible in the standard star data and less than .01 - .02 of a magnitude for the comet picture.

The integrated counts for each comet or standard star coadded picture were processed in a standard manner using the Astronomy Department's standard UBVRI reduction program. The resulting magnitudes for program object were corrected for atmospheric extinction and transformed to the UBVRI system based on standard star observations on the good photometric nights 21, 22, 26 August 1979. The S-20 observations were transformed to the UBVRI system using the relation V(S-20) = 1.85 for (B-V) = 0.66 or solar type colors (Rybski, 1980).

During the reduction of the standard star data, an instrumental effect was discovered in the DAP which caused a star observed with 200 frame integration to be 0.06 magnitudes fainter than the same star observed with a 600 frame integration. The increase in brightness with integration time is due to accumulated phosphor glow. The effect appears to be the same for different intensity levels which encompass the range of the standard stars and comet or sky background. Since all standard stars had 200 frame integrations for S-20 and all comet observations were 600 frames in length, the UBVRI-determined comet magnitudes needed to be 0.06 magnitudes brighter. This correction has been applied to the final column in Appendix 1. No correction is needed for B or V observations because the same 600 frame integration time was used. This correction changes the transformation relation for V(S20) to $1^{m}.79$.

The moderate seeing we had in August did not allow the proposed test of a star versus a comet intensity profile to look for coma activity and measure the size of the coma. In all pictures the comet looked stellar when comet track rates were used. If the seeing had been less than one arcsecond on August 21 during the outburst, we would have been able to confirm the existence of a coma larger than 8000 km.

The comet photometry for the S-20 magnitudes was calibrated in three ways: (1) Differential with the 38 x 38 arcsec frame when a star was available in the frame. The method allowed us to observe during nonphotometric conditions, since both the star and comet suffered the same extinction. We were fortunate to have nearby comparison stars on each of the photometric nights, although near occultations of the comet and stars created serious problems on 24 and 26 August. (2) Normal differential photometry by alternating between comet and star frames using nearby 18th magnitude stars. This method severely reduced the comet brightness sampling interval but it allowed us to intercompare all 4 DAP nights in August by observing the two local standard stars on each night. (3) Normal standard star photometry using observations of standards in the Purgathofer selected areas (1979) and in N7078 (Sandage, 1970). This method was used on the three photometric nights to obtain extinction corrections and transformations to the UBVRI system. Mean extinction coefficients were used with two standard star observations on 24 August to determine the transformations to the UBVRI system. A discussion of the photometry data for each night follows. Each night consisted of standard star observations early in the evening then a concentrated run on P/Encke when it was near the meridan followed by standards at dawn. The P/Encke observations were interspersed with integrations on local standards for the night. The P/Encke data

V(S20), which are presented in Figures 1 - 4, have been processed through the UBVRI calibration, then differentially normalized to the local standard for the night. Stars 1 and 2 were observed on all nights. The stability of the DAP system can be judged from the data presented in the following table of M_{S20} measurements of stars 1 and 2.

S20 Magnitudes for local standards ($=M_{S20}$)

Date	Star 1	Star 2
8/21	16.01±.06	15.40±.13
8/22	16.03	15.28
8/24	15.92	15.33
8/26	16.01	15.29±.06

21 Aug

This night was the most productive night and the scatter in the standard star fits was ±0.01 magnitude compared to the other nights when the fits were ±0.04 to ±0.05 of a magnitude. The four hours of coverage on P/Encke shown in Figure 1 were not extensively interrupted by the necessity of observing comparison stars. Star 1 was in the same 38 x 38 arcsec picture as P/Encke but did not get close enough to P/Encke to cause problems. On other nights, the nightly standards got close enough so that their images coalesced into a single seeing disk (labeled "occultation" on Figures 3 and 4).

The V(S20) magnitude of 18.25 appears to be constant over 4 hours within a scatter of ±0.07 which is similar to the ±0.06 scatter for Star 1. The reason for a lack of a systematic variation may be: (1) that the nucleus of P/Encke does not have significant albedo or shape variations which cause fluctuations in the light curve, or (2) the fact that P/Encke appeared more than a magnitude brighter on this night than on any of the three subsequent nights which were near the brightness level predicted by Yeomans (1979) and the outburst may mask any nuclear albedo or shape variations.

22 Aug

The mean level of 19.54±.20 is 1.3 magnitudes fainter than the previous night, whereas the various checks on the sensitivity and stability of the DAP show less than 0.02 magnitude shift. The local standard for the night, Star 4, was fairly constant over the four hour period although the number of integrations was small because it was not in the same DAP picture as P/Encke. The systematic decline from about

V(S20) = 19.3 to 19.7 may be either a continuation of the outburst decline which must have taken place during the previous 24 hours or an effect of the rotation of an albedo feature. Unfortunately the number of sample points is small and not continuous due to the necessity of observing comparison and standard stars.

24 Aug

The night of 24 Aug started and ended with photometric conditions. But a passing band of light cirrus along with a near occultation of Star 6 wiped out the center of the 4-hour sampling period. Star 6 was not as stable a reference star as the other comparison stars were, but the ±0.11 variation could be explained by "unseen" clouds during the observations. The attempt to remove the effects of clouds just after the near occultation by differential photometry with respect to Star 6 in the same picture worked reasonably for cloud extinctions on the order of one magnitude, but did not work for the two following integrations taken when the extinction was 1.5 magnitudes as determined from Star 6 observations. The conclusion to be drawn from the 24 Aug data is that P/Encke was at the 19.39±.09 magnitude level or about 1.2 magnitudes fainter than three days earlier. Because we did not have a good clear observation of Star 6, we could not reliably remove it from the remainder of the DAP pictures for the night during the period when the two images were in contact or had coalesced. Standard techniques for removing a background star image from a comet plus star image do not work when the star is smeared out due to the comet's motion.

26 Aug

Again a near occultation caused problems at the several tenths of a magnitude level at the beginning of the night. The frame differential method removed the majority of the phosphor glow problems around 0730 UT. The overall downward slope from 18.6 to 19.5 cannot be reliably interpreted due to the large scatter (0.4) in integrations taken close together in time around 1000 hours UT.

BVS20

The notation BVS20 for a few of the data points given in Figures 1 - 4 refers to a separate observing sequence which obtains pictures of 600, 600 and 200 frames in the B, V and S20 bandpasses. This is the same observing sequence used for the standard star measurements. A B, V, and S20 magnitude was measured during these integrations as well as a (B-V) color. The V(S20) magnitudes obtained from the S20 magnitudes with this observing sequence and plotted in Figures 1 - 4 appear to be systematically about 0.3 magnitudes low for all nights. The reason for this discrepancy is not known and can only be partially accounted for by the number of frames in the exposure (200 versus 600 frames which caused the 200 frame S20 observation to be 0.06 of a magnitude low as noted earlier). Regardless of the systematic differences between the V(S20) magnitudes determined from the BVS20 sequence and the S20 sequence, the actual calibration of the B, V and (B-V) magnitudes should be good to the accuracy of the extinction and transformation solution (∿.01 to .05).

The following table compares the observed V magnitudes with those predicted by Yeomans (1979).

Date	r	Mv	Mean $\overline{V(S20)}$	Time	V	(B-V)
1979	(AU)	(Yeomans)		[illegible]		
8/21	3.970	20.09	18.25±.07	0723	18.37	0.46
				0737	18.32	0.53
8/22	3.968	20.08	19.54±.20	0726	19.26	0.93
				0941	19.54	0.85
8/24	3.964	20.05	19.39±.09	---	---	---
8/26	3.960	20.02	19.13±.35	0809	19.84	0.37
				0823	19.46	0.86

With the exception at 0809 hrs on 26 August the (B-V) values are consistent with the comet being bluer during outburst (21 August) than when it is near normal levels. If the observations on 22, 24, 26 August are at the normal level for P/Encke, it is about 0.5 magnitudes brighter than Yeoman's predictions. If additional V(S20) measurements had been obtained in September and November, we might be able to separate the effects of the 21 August outburst and the mean brightness level for the nucleus.

Technical Discussion — Spectrophotometry

The image dissector scanner (IDS) spectrograph (Rybski et al., 1977) was used at the 2.7 m Cassegrain focus. The IDS has two slits imaging on a S-20 photocathode which is rastor scanned yielding two independent spectra of 2048 samples or channels each. This spectrograph does automatic sky subtraction with the slit 1 sky observed 52 arcseconds away at a position angle of 270° and the sky for slit 2 at a position angle of 90°. The comet or star and sky spectra were readout and then exchanged between slits 1 and 2 every 120 seconds. The resulting object minus sky and the individual spectra were stored separately on magnetic tape. To complement the blue sensitivity of the new IDS detector, we used a 600 l/mm grating blazed at 3750 Å in 2nd order with a nominal dispersion of 55 Å/mm and resolution 5 Å corresponding to a 4 x 4 arcsec slit width. The greatest instrumental sensitivity to CN emission at 3883 Å was achieved with this setup. The spectrophotometric observations are summarized in Appendix 2.

The data reduction from observed counts per channel to flux per Ångstrom were carried out using standard Astronomy Department reduction programs SPECTRE, DATAMAN and D[illegible] developed by A. Uomoto. The dispersion curves were computed using a 5th order polynomial fit to Neon and Argon emission spectra taken at the mean telescope position of each observation. All spectra were first divided by continuum lamp spectra to remove channel-to-channel sensitivity variations. The differential atmospheric extinction was then removed using mean extinction coefficients for McDonald Observatory. The instrumental response was removed using spectra of standard stars (Stone, 1977) at approximately the same airmass and as near in time as possible. The reduction to absolute fluxes was not possible because the seeing disk for the standard stars overfilled the spectrograph slit (4 arcseconds) for most of the observations. It was not practical to open the slit further due to the faintness of P/Encke with respect to the sky background. The observed flux in ergs s^{-1} cm^{-2} $Å^{-1}$ is plotted versus wavelength for each of the spectra in Figure 5 along with the average flux within 100 Å bins. The two slits have been coadded to improve the (S/N). A nightly summary of the IDS observing sessions follows.

<u>20 Aug</u>

P/Encke was identified in the field but the partly cloudy weather conditions dictated that we should not attempt to observe a 20th magnitude object.

<u>23 Aug</u>

Although P/Encke was identified in the field of the offset guider for the IDS by the TV system, we could not place P/Encke on the slit of the spectrograph due to the presence of a bright star in the TV field which limited the integration time. If one stayed within the safe operating limits of the TV system with the bright star in the field, one could not see P/Encke because it required a much longer integration time. After a couple of attempts, we decided to observe comet P/Van Biesbrock for the remainder of the night.

27 Aug

This was the first night that the new IDS blue detector was operated at full voltage and gain. Consequently the background in the tube was higher than normal. At the start of the night there was an appa.ent separation of one of the image tube optical contacts but in a non-critical spectral region. However, the separation reduced the observed wavelength range to 3650 - 4900 Å. Since this was the last night of the run a decision was made to obtain the best P/Encke spectrum possible. The spectrophotometrically calibrated spectrum shown in Figure 5 and tabulated in Appendix 4 is the final summed result which has been smoothed to 5 Å or instrumental resolution. No reliable features were present in the spectra of either slit at the CN and CO^+ wavelength. Additionally we have plotted the average flux in 100 Å bins as the other solid line. We did detect a positive signal from P/Encke but the final S/N even in the 100 Å bins is not high enough to speculated on the shape of the reflectivity curve which could have been obtained by dividing by the solar flux (Appendix 4) if the S/N had been higher.

The spectrum of MP 44 NYSA which was obtained for a comparison solar spectrum is shown in Figure 6. The data has adequate quality to allow the reflectivity of this asteroid to be determined in this wavelength range for three dates in August. A full treatment of the MP 44 NYSA and P/Van Biesbrock data will appear elsewhere.

Technical Discussion — Polarization

An attempt to measure the bare nucleus polarization of P/Encke was made on 19 September 1979 with the 2.1 m telescope under excellent observing conditions (photometric and 1 arcsec seeing). The position of P/Encke was readily obtained from the 2.7 m TV-acquisition system on the IDS relative to a nearby brighter star. Using continuously updated positions, several attempts were made over the period of about an hour to detect a signal from the unseen comet above the sky background. The accuracy of pointing offsets at the 2 arcsec level and faintness of P/Encke ($\sim 19^{m}.7$) are probably the reasons that no signal was detected in an 8 arcsec aperture against a $21^{m}.0$ per arcsec^2 sky background. No further attempts were made because weather conditions were worse or P/Encke was predicted to be fainter during the remainder of the scheduled observing time for the polarimeter runs during September and October.

Conclusions

P/Encke is not quiescent when near aphelion. An outburst of at least 1.2 magnitudes was observed on 21 August. The lack of any systematic variation (±.07) in the V(S20) magnitude over the 4-hour observing session on 21 August leads to the conclusion that P/Encke lacks significant rotational albedo features when in outburst. The subsequent photometric observations on 22, 24, and 26 August do not have enough continuous time coverage due to clouds or near occultations with faint stars for determination of a rotation period.

A featureless spectrum was obtained on 27 August with the new blue IDS detector. The resulting 100 Å resolution spectrum with a S/N of 2 is insufficient to allow the determination of the reflectivity of P/Encke near perihelion.

Polarization measurements were attempted on 19 September but no signal above the sky background was detected.

Acknowledgements

P. M. Rybski was invaluable to the completion of this project, in particular by the installation and testing of the new blue IDS detector and the TV modifications in August 1979. The dedicated attempts to make polarization observations made by M. Breger are gratefully acknowledged. The authors acknowledge the support of NASA Grant NG4-44-012-152 which provided the funding for telescope time assigned to this project.

New Technology

During the course of this project no reportable items of new technology were developed.

Recommendations

Future observers of faint-moving objects such as comets or asteroids should be aware of the difficulties posed by faint stars moving near the target either in the same seeing disk or in the sky slit of the spectrograph. Ahead-of-time, if possible, the observing track should be accurately laid out on the Palomar survey plates so that different instruments can be used on nights when problems might occur or standards can be observed during these time periods. We followed many such precautions but weather and near occultations played havoc with the planned observations. If at all possible, non-variable comparison stars should be selected for the entire run because significant amounts of observing time can be lost doing too many standard or comparison stars. The advantage of a sensitive area detector and TV-acquisition system cannot be overemphasized because they allow one to see all the other objects which are moving through the field. Standard aperture photometry does not have this capacity and a star 4 or 5 magnitudes fainter than the comet has a significant influence on one's data. This effect is also a problem with the standard stars as can be seen by the fact that some supposed standards we have looked at had objects 3 - 5 magnitudes fainter within our field – and presumably down a photometric aperture – which affected their quality.

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FIGURE CAPTIONS

Figure 1 V(S20) magnitudes from 2.85 minute integrations on P/Encke on 21 August. The magnitudes for P/Encke were calibrated with standard stars and normalized to the S20 observations of Star 1. The integrations were over a 23 x 23 pixel or 13.8 x 13.8 arcsec square aperture centered on the comet position. The BVS20 magnitudes were determined at times indicated by ( ). The solid lines connect sequential integrations and dashed lines indicate nonsequential integrations.

Figure 2 Same as Figure 1 for 22 Aug with respect to Star 4.

Figure 3 Same as Figure 1 for 24 Aug with respect to Star 6.

Figure 4 Same as Figure 1 for 26 Aug with respect to Star 8.

Figure 5 Calibrated flux (ergs cm^{-2} s^{-1} $Å^{-1}$) for P/Encke on 27 Aug 79. IDS slits 1 and 2 have been combined and the resolution is 5 Å FWHM.

Figure 6 Same as Figure 5 for MP 44 NSYA.

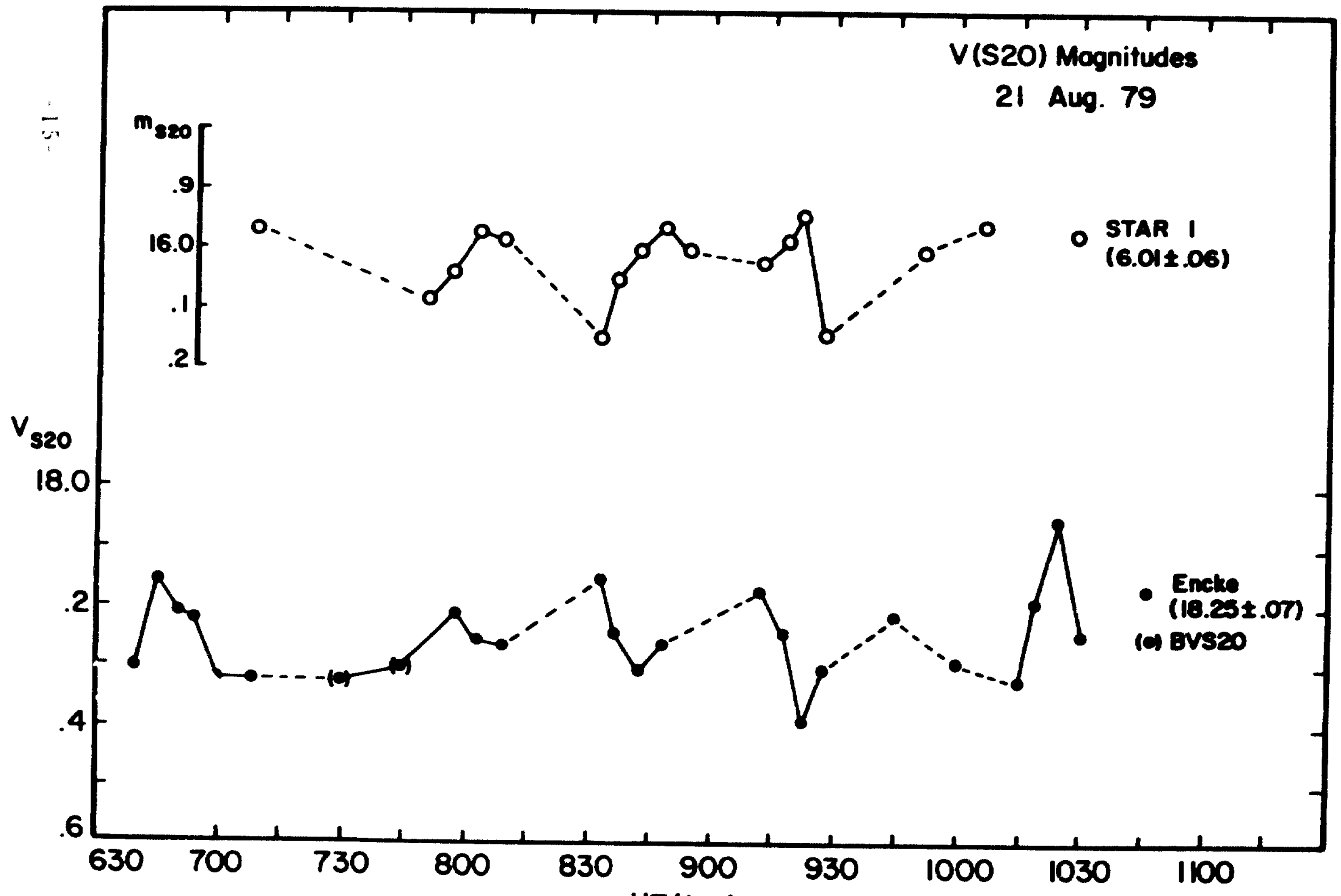
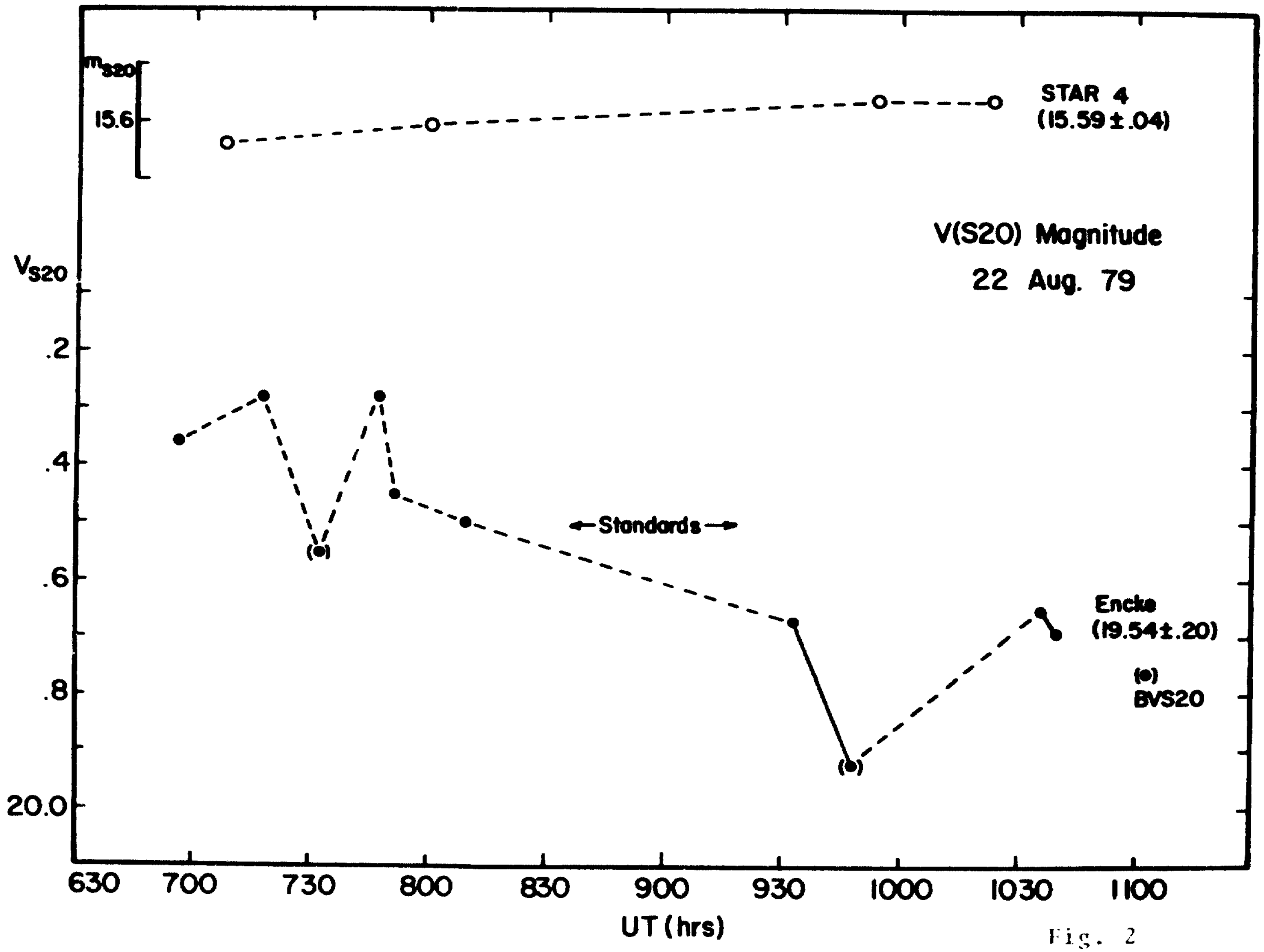

V(S20) Magnitudes
21 Aug. 79
m_{S20}
.9
16.0
.1
.2
STAR I
(6.01±.06)
V_{S20}
18.0
.2
.4
.6
Encke
(18.25±.07)
(•) BVS20
630
700
730
800
830
900
930
1000
1030
1100
UT (hrs)

Fig. 1



STAR 4
(15.59±.04)
V(S20) Magnitude
22 Aug. 79
Standards
Encke
(19.54±.20)
(•)
BVS20
m_{S20}
15.6
V_{S20}
.2
.4
.6
.8
20.0
630
700
730
800
830
900
930
1000
1030
1100
UT (hrs)

Fig. 2

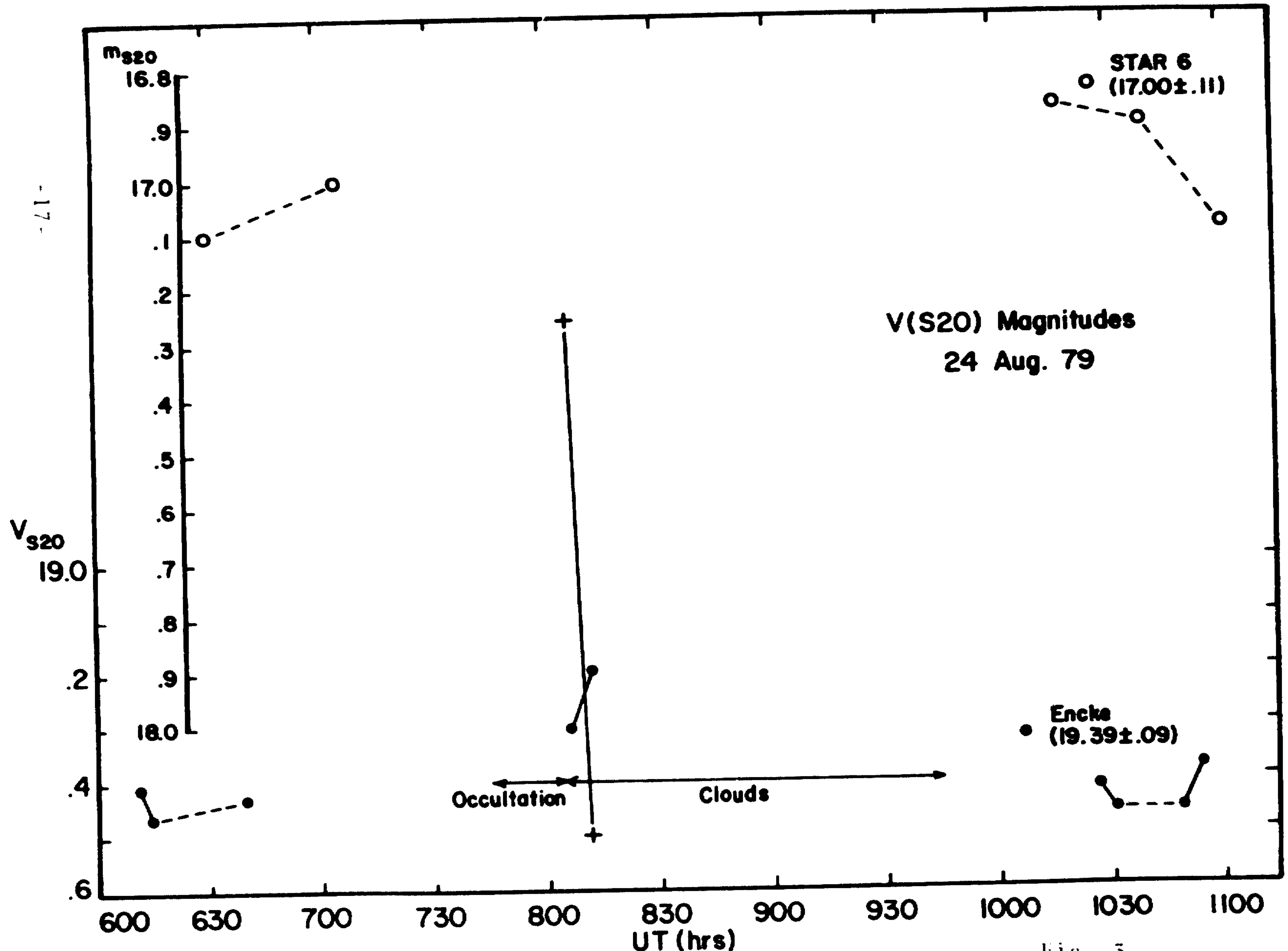

STAR 6
(17.00±.11)
V(S20) Magnitudes
24 Aug. 79
Encke
(19.39±.09)
Occultation
Clouds
m_S20
16.8
.9
17.0
.1
.2
.3
.4
.5
.6
.7
.8
.9
18.0
V_S20
19.0
.2
.4
.6
600
630
700
730
800
830
900
930
1000
1030
1100
UT (hrs)

Fig. 5

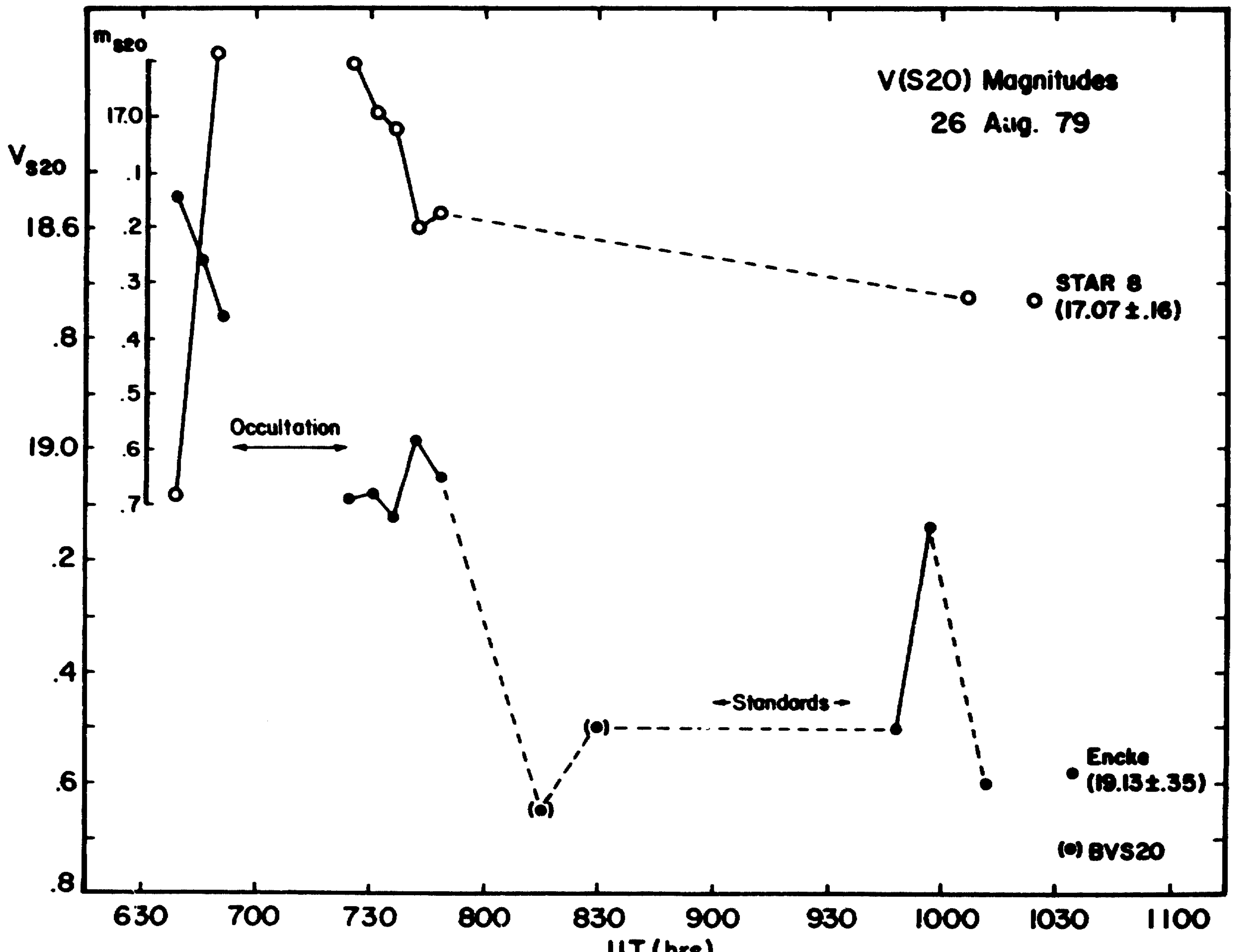
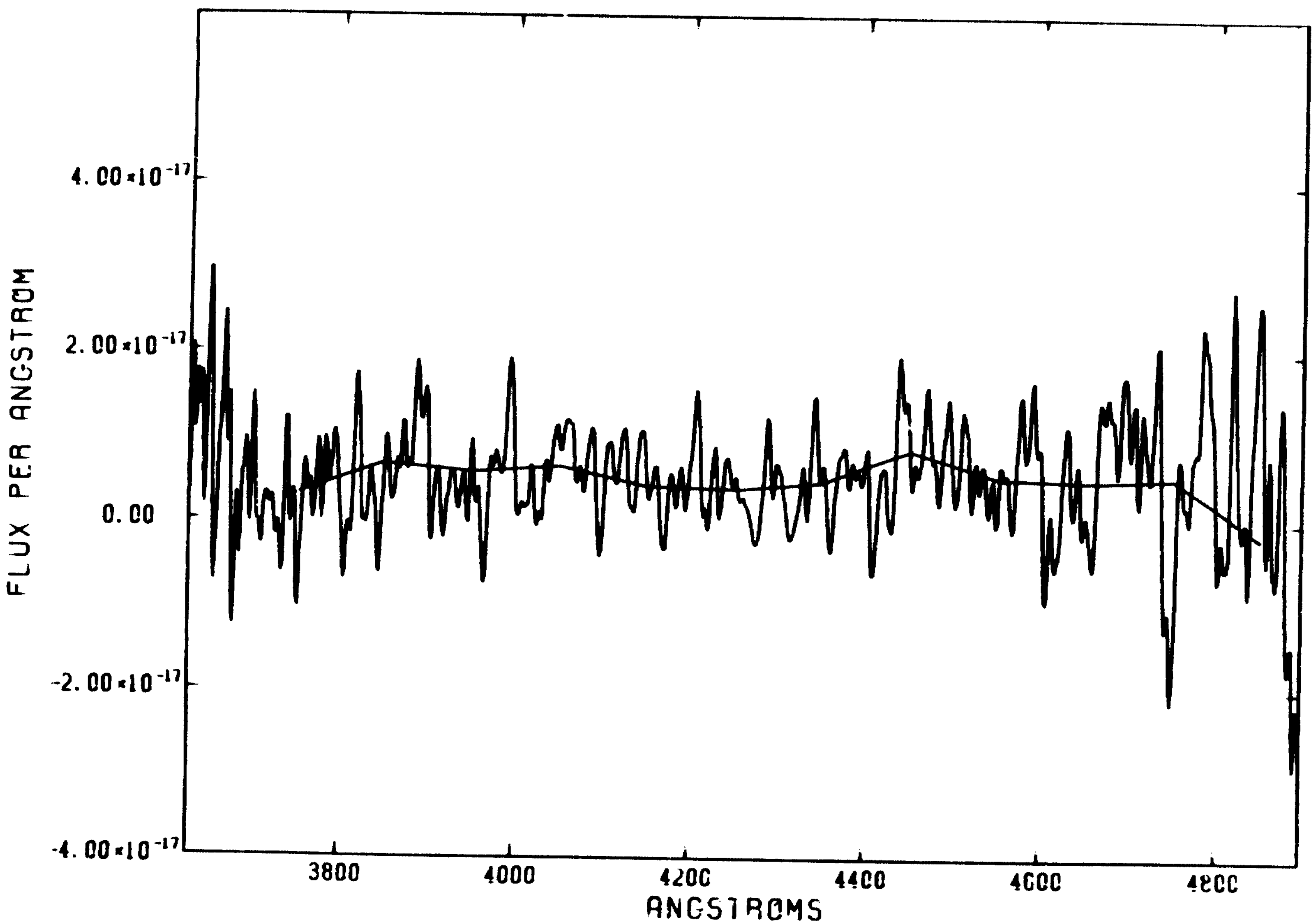
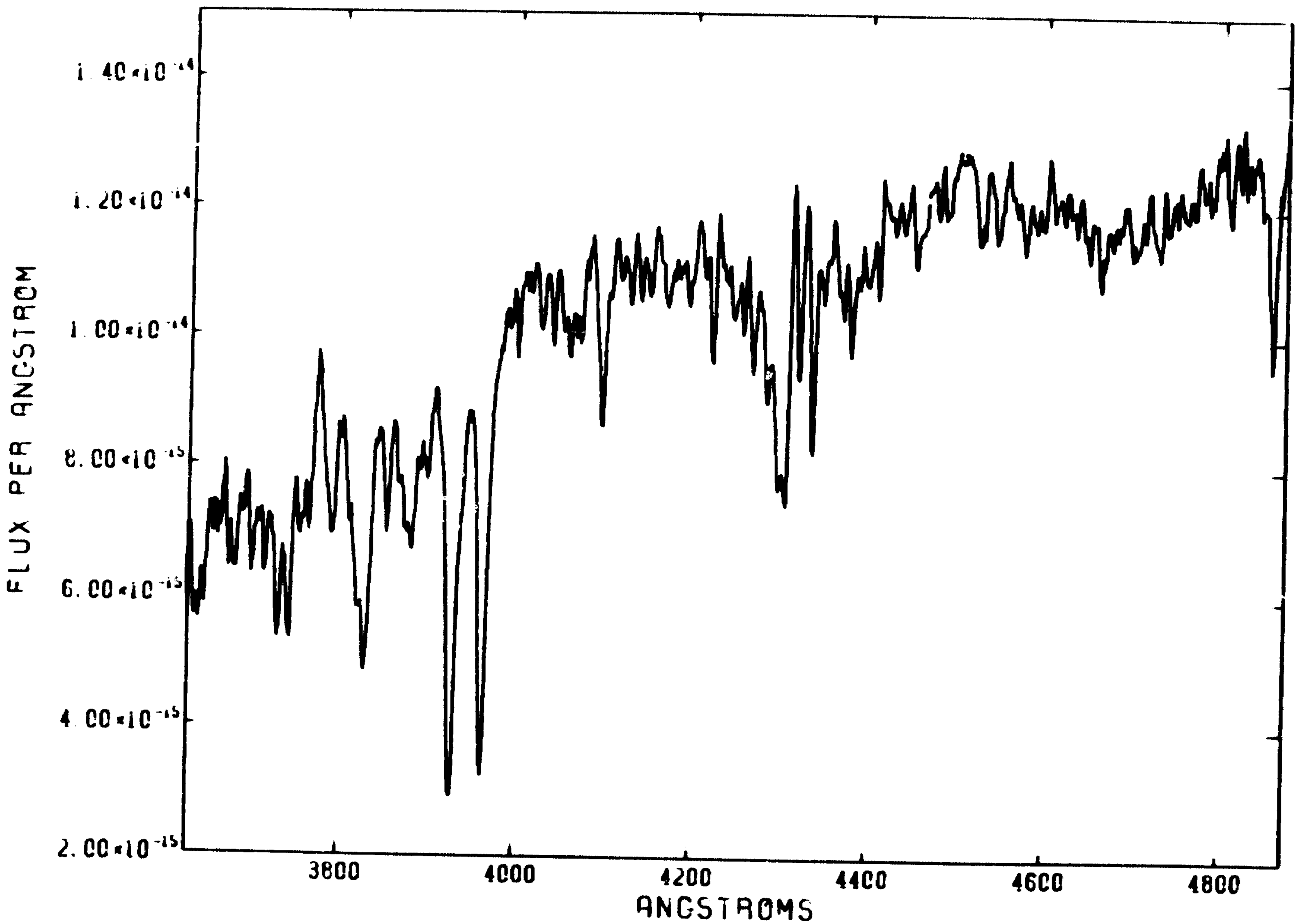

V(S20) Magnitudes
26 Aug. 79
V_{S20}
m_{S20}
17.0
.1
.2
.3
.4
.5
.6
.7
18.6
.8
19.0
.2
.4
.6
.8
Occultation
STAR 8
(17.07 ± .16)
Standards
Encke
(19.13 ± .35)
(•) BVS20
630
700
730
800
830
900
930
1000
1030
1100
UT (hrs)

Fig. 4



CALIBRATED ENCKE SUM AUGUST, 1979

Fig. 5



M. P. 44 NYSA SUM SLITS 1+2 27AUG79

Fig. 6

APPENDIX 1

DAP Photometry: P/Encke

Label	Mean Time	Airmass	Star 1	Comet	Comet
8/21/79	(UT)		M_{S20}*	M_{S20}	V(S20)**
EN790821SF.51	0640	1.302	16.01	16.51	18.30
" .52	0645	1.291	16.01	.37	.16
" .53	0650	1.278	16.01	.42	.21
" .54	0654	1.265	16.01	.43	.22
" .55	0659	1.254	16.01	.40	.19
S1790821SF.51	0708	1.235	16.01	.49	.32
EN790821SF.56	0715	1.222	15.98	.50	.32
" .57	0730	1.202	16.03	(.55)	(.32)
" .58	0744	1.185	16.07	(.57)	(.30)
" .59	0758	1.171	16.04	.45	.21
" .60	0803	1.168	15.97	.42	.25
" .61	0808	1.165	15.98	.44	.26
" .62	0832	1.161	16.15	.50	.15
" .63	0837	1.162	16.05	.49	.24
" .64	0843	1.163	16.00	.50	.30
" .65	0848	1.165	15.96	.42	.26
" .66	0911	1.182	16.02	.39	.17
" .67	0917	1.188	15.99	.43	.24
" .68	0922	1.194	15.94	.53	.39
" .69	0927	1.200	16.14	.64	.30
" .70	0944	1.228	16.04	.48	.21
" .71	0959	1.258	15.98	.47	.29
" .72	1014	1.297	15.96	.48	.32
" .73	1019	1.314	16.01	.40	.19
" .74	1024	1.330	16.01	.26	.05
" .75	1029	1.346	16.01	.45	.24
			16.01		18.25
			±.06		±.07
			(16)		(26)

Label	Mean Time	Airmass	Star 4	Comet	Comet
8/22/79	(UT)		M_{S20}*	M_{S20}	V(S20)**
EN790822SF.51	0656	1.257	15.59	17.57	19.36
" .52	0718	1.214	.64	.49	.28
" .53	0732	1.194	.63	(.76)	(.55)
" .54	0747	1.178	.62	.49	.28
" .55	0752	1.174	.62	.66	.45
" .56	0810	1.164	.61	.71	.50
" .57	0932	1.213	.57	.88	.67
" .58	0947	1.238	.56	18.13	.92
" .59	1035	1.376	.56	17.86	.65
" .60	1040	1.396	.56	.90	.69
			15.59		19.54
			±.04		±.20
			(4)		(10)

Label	Mean Time	Airmass	Star 6	Comet	Comet
8/24/79	(UT)		M_{S20}*	M_{S20}	V(S20)**
EN790824SS.51	0611	1.343	17.00	17.62	19.41
EN790824SF.51	0619	1.333	17.00	17.68	19.47
" .52	0640	1.273	17.06	17.70	19.43
" .53	0655	1.242	---	18.37	track error
" .54	0713	1.207	---	18.07	track error
" .55	0800	1.166	---	16.99	"occultation"
" .56	0806	1.164	17.26	17.77	19.30
" .57	0811	1.163	18.02	18.44	19.21
" .58	0817	1.163	---	18.79	clouds
" .59	0821	1.163	---	18.65	clouds
" .60	1026	1.379	16.88	17.51	19.42
" .61	1031	1.402	16.89	17.56	19.46
" .62	1048	1.475	16.98	17.65	19.46
" .63	1053	1.506	17.02	17.59	19.38
			17.00		19.39
			±.11		±.09
			(5)		(9)

Appendix 1 (con't)

Label	Mean Time	Airmass	Star 8	Comet	Comet
8/24/79	(UT)		M_{S20}*	M_{S20}	V(S20)**
EN790826SF.52	0639	1.250	17.68	17.36	18.54
" .53	0646	1.236	16.89	.69	.66
" .54	0651	1.227	16.63	.41	.76
" .55	0710	1.197	---	16.42	"occultation"
" .56	0725	1.181	16.90	17.13	19.09
" .57	0731	1.177	16.99	.21	.08
" .58	0736	1.174	17.02	.28	.12
" .59	0742	1.170	17.20	.32	18.98
" .60	0747	1.168	17.17	.36	19.05
" .61	0815	1.166	17.20	(.99)	(.65)
" .62	0829	1.172	17.22	(.86)	(.50)
" .63	0948	1.299	17.30	.94	.50
" .64	0956	1.285	17.31	.59	.14
" .65	1011	1.389	17.32	18.06	.60
			17.07 ±.16 (7)		19.13 ±.35 (13)

* interpolated differential
** final corrected transformed
( ) BVS20 measurement

DAP Photometry: Differential Standard Stars

Date (1979)	Star	Label	Time (UT)	Airmass	M_{S20}
21 Aug	Star 1	S1790821SF.51	0708	1.235	15.96
		" .52	0751	1.176	16.08
		" .53	0854	1.168	16.00
		" .54	1006	1.275	15.96
		" .55	0951	1.243	16.00
		EN790821SF.59	0758	1.171	16.04
		" .60	0803	1.167	15.97
		" .61	0811	1.165	15.98
		" .62	0832	1.161	16.15
		" .63	0837	1.162	16.05
		" .64	0843	1.163	16.00
		" .65	0848	1.165	15.96
		" .66	0911	1.182	16.02
		" .67	0917	1.188	15.99
		" .68	0922	1.194	15.94
		" .69	0927	1.200	16.14
					16.01±.06(16)

Date (1979)	Star	Label	Time (UT)	Airmass	M_{S20}
	Star 2	S2790821SF.51	0816	1.162	15.32
		" .52	0824	1.161	15.41
		" .53	0903	1.174	15.34
		" .54	0936	1.214	15.62
		" .56	1036	1.368	15.29
					15.40±.13(5)
22 Aug	Star 1	S790822SF.51	1005	1.281	16.03
	Star 2	S2790822SF.51	1012	1.297	15.28
	Star 3	S3790822SF.51	0708	1.230	17.54
		" .52	0801	1.168	17.70
		" .53	0955	1.257	17.42
		" .54	1024	1.337	17.56
					17.56±.11(4)
	Star 4	S4790822SF.51	0708	1.230	15.64
		" .52	0801	1.168	15.61
		" .53	0955	1.257	15.56
		" .54	1024	1.337	15.56
					15.59±.04(4)
	Star 5	S5790822SF.51	0739	1.168	15.81
		" .52	0817	1.162	15.86
		" .53	1017	1.426	15.83
					15.83±.03(3)
24 Aug.	Star 1	S1790824SF.51	0742	1.175	15.92
	Star 2	S2790824SF.51	0735	1.183	15.33
	Star 6	S6790824SF.51	0629	1.302	17.10
		" .52	0705	1.221	17.01
		" .53	1018	1.349	16.87
		" .54	1039	1.432	16.90
		" .55	1101	1.546	17.10
		EN790824SF.56	0806	1.164	17.26
		" .57	0811	1.163	18.02
		" .58	0817	1.163	18.50
		" .59	0821	1.163	18.77
					17.00±.11(5)

Date (1979)	Star	Label	Time (UT)	Airmass	M_{S20}
26 Aug	Star 1	S1790826SF.51	0908	1.199	16.01
	Star 2	S2790826SF.51	0918	1.209	15.33
		" .52	0921	1.218	15.24
					15.29±.06(2)
	Star 7	S7190826SF.51	0555	1.378	17.15
		" .52	0756	1.166	16.96
		" .53	0836	1.177	17.12
		" .54	0935	1.263	17.09
		" .55	1024	1.422	17.13
					17.08±.08(5)
	Star 8	S8790826SF.51	1006	1.352	17.32
		EN790826SF.52	0639	1.252	17.68
		" .53	0646	1.236	16.89
		" .56	0725	1.182	16.90
		" .57	0731	1.177	16.99
		" .58	0736	1.174	17.02
		" .59	0742	1.170	17.20
		" .60	0747	1.168	17.17
					17.07±.16(7)

APPENDIX 2

IDS Spectra of P/Encke and Standard Stars

Date	Object	Start (UT)	Total Exp.Time (min)	Airmass	λλ Range (Å)	Resolution (Å)	Slit Size (arcsec)
20 Aug	P/VanBiesbrock	0938	17	1.36	3650-5150	5	4 x 4
	BD+25°3941	0405	2	1.01	"	"	"
23 Aug	BD+25°3941	0421	2	1.00	"	"	"
	BD+40°4032	0433	2	1.02	"	"	"
	P/Encke	0751	8	1.16	"	"	"
	P/VanBiesbrock	0923	27	1.35	"	"	"
	MP 44 NYSA	1122	15	1.32	"	"	"
27 Aug	Feige 110	0530	3	1.50	"	"	"
	P/Encke	0733	25	1.18	"	"	"
	P/Encke	0903	57	1.22	"	"	"
	MP 44 NYSA	1051	13	1.30	"	"	"

APPENDIX 3

Standard Stars used for Photometric DAP Reductions

SA ~ Selected Area
SS ~ Star Number

Label	RA (1979)	Dec (1979)	V	B-V	U-B	V-R	V-I
		Purgathofer (1979)					
SA71SS37	$03^h15^m48^s$	+15°25.8'	16.75	0.21	-0.77	0.18	2.07
SA71SS35	03 15 54	+15 21.9	15.58	1.32	0.81	0.71	1.92
SA82SS37	14 19 14	+15 07.1	15.36	0.73	0.49	0.43	1.85
SA82SS39	14 18 39	+15 09.5	15.54	1.06	0.81	0.59	1.86
Aquila39	19 00 36	+04 49.5	15.68	1.03	0.66	0.57	1.85
Aquila36	19 00 32	+04 52.4	14.86	1.24	0.55	0.67	1.89
		Sandage (1970)					
N7078X13	21 29 43	+12 00.2	15.18	1.21	1.21	0.66	1.90
N7078X10	21 29 37	+12 01.3	15.02	0.72	0.09	0.43	1.86

Standard Stars used for Spectrophotometric IDS Reductions

Stone (1977)

Name	RA (1975)	Dec (1975)	Sp. Class
Feige 110	$23^h18^m41^s$	-05°18'	sdO
BD+25°3941	19 43 24	+26 10	B1.5 v
BD+40°3	20 07 30	+41 10	B2 III

APPENDIX 4

Fluxes Averaged Over 100 Å
(ergs s^{-1} cm^{-2} $Å^{-1}$)

Wave-length Å	Solar* 10^2	Encke 27 Aug $x10^{-18}$
3750	1.13	3.09
3850	1.05	6.65
3950	1.21	5.69
4050	1.77	6.40
4150	1.88	4.90
4250	1.77	3.82
4350	1.74	4.71
4450	2.01	8.47
4550	2.10	5.21
4650	2.09	4.93
4750	2.11	5.33
4850	1.99	-1.77

* from Arveson _et al._ (1969)