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DETECTION OF RADIAL VELOCITY VARIATIONS IN THE RAPIDLY OSCILLATING Ap STAR HR 1217

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ABSTRACT

We observed the rapidly oscillating Ap (roAp) star HR 1217 on two nights in 1986 December; for radial velocity (RV) variations with the 3.6 m Canada-France-Hawaii telescope and photometrically with the 0.6 and 2.2 m telescopes of the University of Hawaii. We were searching for velocity oscillations which matched the dominant photometric period of the star at $\sim$6.13 minutes. On the first night, the peak-to-peak photometric variations in Johnson B were only 1.8 mmag and no significant velocity variation above 130 m s^{-1} was seen. On the second night, the photometric amplitude had risen to 6.8 mmag with corresponding velocity variations of 400 ± 50 m s^{-1}. This is the first detection of rapid RV variations in an roAp star, and the first *direct* evidence that these stars are indeed pulsating variables. The latter results give a RV-to-light amplitude ratio ($2\,K/\Delta m_B = 59 \pm 12$ km s^{-1} mag^{-1}) and a phase lag ($\Delta\Phi = 0.045 \pm 0.005$ cycles). These values are inconclusive as a test of whether the roAp stars are related to the δ Scuti pulsators. However, the modulation of the RV and light amplitudes of HR 1217 over the two nights provides additional support for Kurtz's (1982) oblique pulsator model for the roAp stars.

Subject headings: stars: individual (HR 1217) — stars: peculiar A — stars: variable

I. INTRODUCTION

The rapidly oscillating Ap (roAp) stars are cool, peculiar A–F V stars which vary in broad-band light with periods from $\sim$4 to 20 minutes with typical amplitudes of a few millimagnitudes. Comprehensive reviews of the class, which currently includes 12 variables, have been written by Kurtz (1986*a*), Weiss (1986), and Shibahashi (1987).

The photometric oscillations of the roAp stars have been attributed to nonradial pulsations; in particular, p-modes of low degree ($l \leq 3$) and high radial order ($n \geq 15$). The most compelling evidence for this is found in the rapid photometry of two roAp stars, HR 1217 (Kurtz and Seeman 1983) and HD 60435 (Matthews, Kurtz, and Wehlau 1987). Both stars exhibit multiple oscillations which are nearly equally spaced in frequency as predicted by Tassoul's (1980) theory for p-mode pulsations (where $n \gg l$) and observed in the Sun's "five-minute" oscillations in integrated light (Woodward and Hudson 1984).

Unfortunately, analogy with the solar case is necessarily limited by the "large" amplitude of the roAp oscillations (at least three orders of magnitude higher than the Sun's) and the distinctly nonsolar nature of the peculiar A stars (e.g. strong global magnetic fields, anomalous abundances in the upper atmospheres). It seems unlikely that the Sun and the roAp stars share the same driving mechanism. Since the roAp stars fall in or near the lower instability strip, it is attractive to assume that they are governed by the same He II ionization zone mechanism which drives the δ Scuti variables. Problems with this interpretation arise, however, from the periods of the roAp stars (which are much shorter than their δ Scuti counterparts) and the apparent deficiencies of helium in the upper atmospheres of peculiar A stars. To address these difficulties, Shibahashi (1983) proposed an alternate mechanism: *magnetic overstable convection.* In this scenario, magnetic field lines "glued" to the plasma in a superadiabatic region of the stellar atmosphere supply a restoring tension against convective motions, thereby inducing and maintaining oscillations with appropriate periods.

The rapid oscillations of an Ap star differ from the Sun's in another noteworthy respect: they undergo periodic amplitude modulation and (in at least one instance) 180° phase shifts which are synchronized with the variations of the star's magnetic field. Maximum oscillation amplitude coincides with peak field strength, while the phase shifts occur at magnetic quadrature.

This behavior can be explained in terms of Kurtz's (1982) *oblique pulsator* hypothesis. According to this model, a rapidly oscillating Ap star is an oblique rotator (i.e., it has an approximately dipole magnetic field inclined to its rotation axis) which is also pulsating nonradially, such that the pulsation poles are aligned with the oblique magnetic poles. The observed amplitude modulation is therefore a result of seeing different aspects of the pulsation pattern on the visible disk of the star. Furthermore, if the pulsation is zonal ($m = 0$), the phasing of the maximum oscillation amplitude and the phase shifts are natural consequences of the model.

Identification of a mechanism for the roAp phenomenon, and evaluation of the oblique pulsator model, have been handicapped by the fact that (prior to this work) the oscillations of roAp stars have been seen only photometrically. The detection—or *null* detection, to high precision—of radial

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velocity (RV) oscillations in an roAp star was expected to resolve many key questions about the nature of the class:

1. Are these stars truly pulsating?
2. If so, are the RV variations modulated in the same fashion as the light variations, as is predicted by the oblique pulsator model?
3. What are the values of the RV-to-light amplitude ratio ($2\,K/\Delta m$) and phase lag for the roAp stars, and are they comparable to those derived for the δ Scuti variables?

The difficulties associated with measuring RV oscillations in the roAp stars are twofold: (i) the light amplitudes are so small that simple considerations lead one to expect RV amplitudes no larger than a few hundred m s^{-1}, and (ii) the oscillation periods are so short that—in order to achieve adequate phase coverage with a straightforward time series of observations—individual exposures have insufficient signal-to-noise (S/N) for use in precise RV measurements.

We are aware of only three previous attempts to detect velocity oscillations in known roAp stars. Balona (see Kurtz 1982) searched for such variations in HR 1217 using a Griffin-type radial velocity spectrometer at the South African Astronomical Observatory, but could establish only an upper limit of 2 km s^{-1} from his data. Two later efforts to measure RV oscillations in γ Equ and α Cir have been described by Weiss *et al.* (1987). No detection was made in either case.

The prime candidate for our program was the rapid oscillator HR 1217 ($V = 6.0$, sp A5p), which oscillates with periods centered near 6.14 minutes and a peak B amplitude of 0.014. This star was selected as one of the best-studied in the roAp class. The mean oscillation period of this star has remained constant over an interval of more than 3 yr (Kurtz 1982; Kurtz and Seeman 1983; Kurtz, Schneider, and Weiss 1985; hereafter KSW). Its amplitude is modulated with a period of $12^{\rm d}.4564$, which is also the magnetic and long-term spectroscopic period of the star (Bonsack 1979). The photometric observers cited above were able to use an ephemeris for HR 1217, based on long-term photometry and Eu II line strength data, to predict accurately times of oscillation maximum. We adopted the same ephemeris (from KSW) in selecting the optimum times for our observations, with the rationale that times of light oscillation maximum should correspond to times of RV maximum if the oblique pulsator interpretation is correct.

II. OBSERVATIONS AND REDUCTION

a) Spectroscopy

These observations were made with the Canada-France-Hawaii 3.6 m telescope using the blue coudé train, f/8.2 four-grating mosaic (600 mm^{-1}) spectrograph, "CFHT blue" image slicer (Brealey *et al.* 1980), and RL1872F/30 Reticon detector (Walker, Johnson, and Yang 1985) on 1986 December 15 and 16 UT. The dispersion was 0.101 Å diode^{-1} (6.9 Å mm^{-1}) with a spectral coverage, $\sim$4335–4520 Å. After the first night, a slight error in the collimation of the telescope was recognized and corrected.

The stellar exposures were synchronized with the primary light oscillation period of HR 1217 (6.126 ± 0.001 minutes)[3] such that each exposure began at a time $t_i = t_0 + n \times \Delta t$, where $\Delta t = (0.1 \times \text{the photometric period}) = 36.76$ s, n is an integer, and t_0 is an arbitrary epoch. A new Reticon control/data acquisition program was implemented to facilitate efficient and accurate timing of the observations. To allow time for two 1 s baseline exposures and software overhead while writing exposures to disk, each stellar exposure was limited to 33 s. The observing routine consisted of a series of automatic sequences of up to 100 stellar exposures (plus baselines), each followed by Fe-Ar arc, flat-field lamp, and dark exposures.

[3] As mentioned in § I, HR 1217 is multiperiodic, exhibiting at least six periods. We selected the period of the oscillation with the largest mean amplitude (KSW) as the time base for our spectroscopy.

Most of the earlier precision radial velocity work carried out at CFHT has made use of the HF absorption cell technique, in which absorption lines of hydrogen fluoride are imposed on the stellar spectrum by passing the starlight through a cell containing HF gas, placed in front of the spectrograph slit. This approach, while very successful in studies of later type stars (see e.g., Walker *et al.* 1984) and longer period δ Scuti variables (e.g., Yang and Walker 1986), was not practical in this case because Ap stars have too little continuum flux and too few lines in the near-IR range where the HF band is found.

Instead, light from a small mercury discharge lamp was introduced directly into the coudé telescope beam. The Hg emission line at λ4358 was imposed in every stellar spectrum to allow us to monitor small spectrograph wavelength instabilities. At the beginning of both nights, a "standard" spectrum of HR 1217—*without* the Hg line—was obtained. Exposure times for the standards on the two nights were 900 and 1000 s, respectively. These standards were used to remove the stellar contribution from the (star + Hg λ4358) spectra when measuring the positions of the Hg line.

On the first night, 510 stellar exposures were obtained; on the second, 600. A typical value for the S/N of an individual spectrum on either night was roughly 20, although ratios as high as 60 were reached. The data were reduced using the University of British Columbia version of the RETICENT program (Pritchet, Mochnacki, and Yang 1982). Each stellar spectrum was corrected for baseline and dark background and normalized with respect to a continuous lamp spectrum. The lamp illuminated a diaphragm which isolated the telescope exit pupil. The gains of the four video-line outputs for the Reticon were adjusted to the same value. Any long-term drift in the zero-point of the detector array was estimated from the line positions in the Fe-Ar arc spectra collected during each night. A linear fit to these zero-point shifts was subtracted from the stellar spectra. Shifts induced by barycentric motions (calculated using the algorithms of Stumpff [1980]) were also removed.

After the spectra were reduced in this way, all those on a given night which were recorded at the same oscillation phase were added, resulting in 10 binned spectra per night. The S/N of each of these spectra is about 150 for the first night, and 160 for the second. An example of one of these spectra, in which the Hg reference line is truncated to show the stellar lines at a reasonable scale, is presented in Figure 1.

To search for RV shifts between the spectra, the Fahlman-Glaspey difference-function technique (Fahlman and Glaspey 1973) was employed. Because of the relatively low S/N of each binned spectrum, shifts derived from individual lines will have high uncertainties. Therefore, the cross-correlation was carried out on a large portion of the spectrum, extending from 4370 to 4515 Å, which contains many stellar lines but avoids the Hg emission line. Shifts were first determined relative to one of the binned spectra. Then, the other nine spectra were corrected for these first-order shifts, added along with the first, and averaged. The shifts of all 10 spectra were then calculated relative

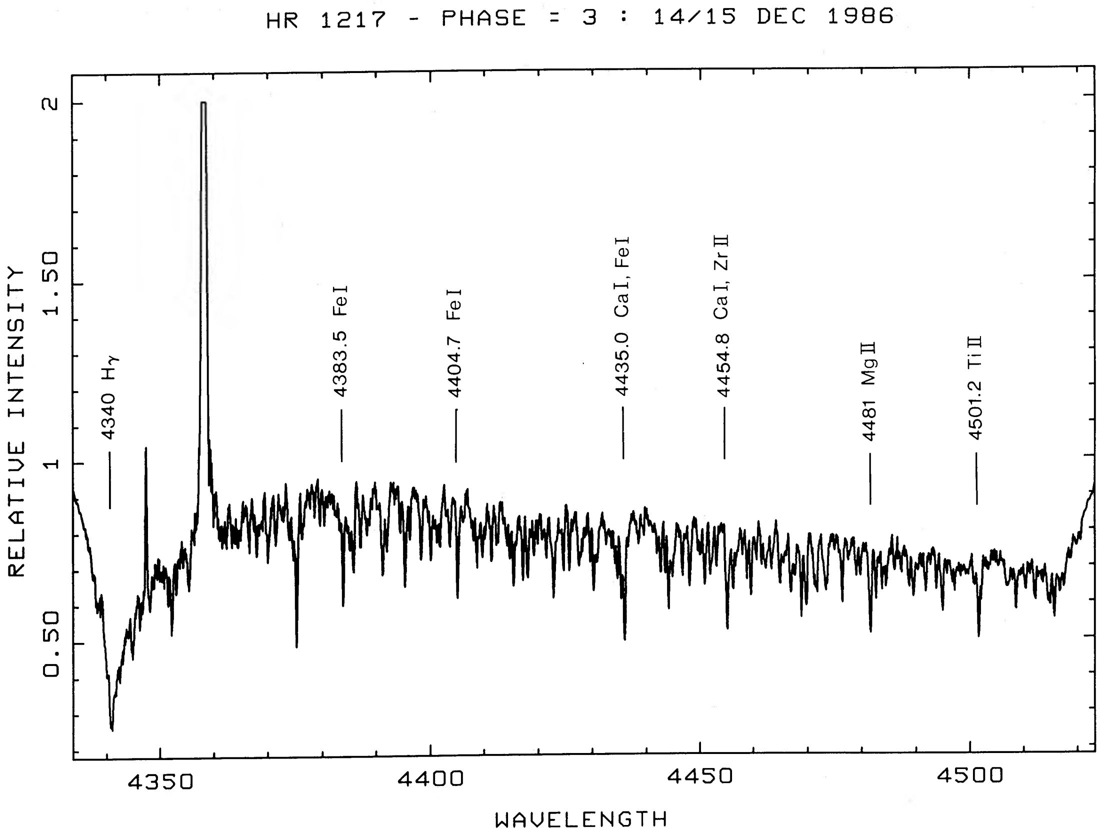

FIG. 1.—One of the 10 binned spectra of HR 1217 from 1986 December 16 UT. The Hg emission line at λ4358 has been truncated in this plot; at this scale, the line peaks at a relative intensity of ~20. A few prominent lines in the stellar spectrum are labeled.

to this mean spectrum, with its improved S/N. Because the accuracy of the difference-function technique depends on the individual S/N ratios of both spectra being correlated, the use of the mean spectrum reduces the standard errors of the shift estimates.

As a check that any apparent velocity shifts seen in the stellar spectra did not originate in the instrument, relative shifts of the Hg reference line were calculated in the same way. The S/N of the Hg line ranged between about 400 and 1000, so even though only a single line was being measured, the standard error of the resulting shifts is somewhat smaller than that of the stellar measurements.

Note that, since each binned spectrum is a composite of spectra exposed throughout the ~7 hr interval during which HR 1217 was observed, the effects of long-term drifts due to guiding errors, barycentric motions, etc., were averaged out. Our removal of these effects from the spectra serves primarily to increase the sharpness of the lines used for the cross-correlation, and hence, to improve the accuracy of any measured stellar shifts. Any residual non-stellar shifts are unlikely to produce *systematic* variations from one binned spectrum to another. However, they will manifest themselves as random scatter in the velocity curves (see § III).

b) *Photometry*

On the same nights as the CFHT spectroscopy, rapid broadband photometry of HR 1217 was obtained using the 2.2 m telescope (~$1\frac{1}{2}$ hr on December 15 UT) and the 0.6 m "Air Force" telescope (~5 hr on December 16 UT) of the University of Hawaii[4] by J.M.M. and W.H.W. Both sets of observations were made with the same single-channel photometer equipped with an RCA C31034 (S-20) photomultiplier tube. Measurements were made through an "asteroid b" filter; in combination with the S-20 phototube, its response is essentially equivalent to a Johnson *B* bandpass. To avoid edge effects and guiding errors, large diaphragms were used, with diameters of 55″ (0.6 m telescope) and 30″ (2.2 m).

The photometric observing routine consisted of nearly continuous 10 s integrations of HR 1217, interrupted by occasional measurements of sky brightness. (Due to software overhead in the data acquisition system of about 2.1 s per integration, starting times of measurements were spaced by about 12 s.) The rapid sampling interval did not permit use of a comparison star; as a result, extremely stable skies were required to detect the low-amplitude oscillations. The integrations (adjusted for changes in sky background) were converted to instrumental magnitudes and corrected for mean atmospheric extinction. The two resulting light curves are shown in Figures 2*a* and *b*.

On both nights, oscillations with a period near 6 minutes are readily apparent in the data. Modulation over a time scale of hours is also evident, presumably the effect of beating among the six or more periods in HR 1217. Fourier analysis of the photometry (using the routine described by Matthews and

[4] These two nights of photometry, along with 11 others collected using the 0.6 m telescope during 1986 December 3–19, were also part of a coordinated international campaign to monitor the oscillations of HR 1217 (Kurtz 1986*b*).

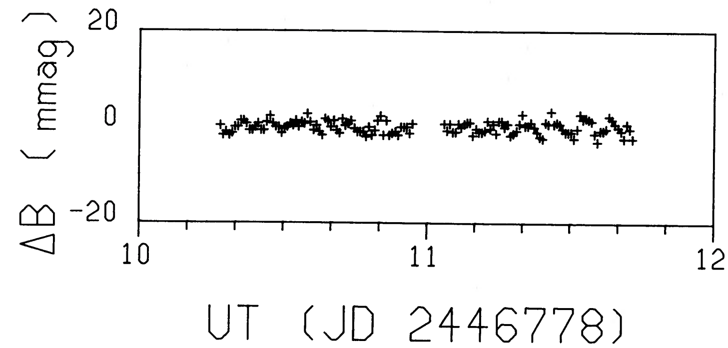

FIG. 2a

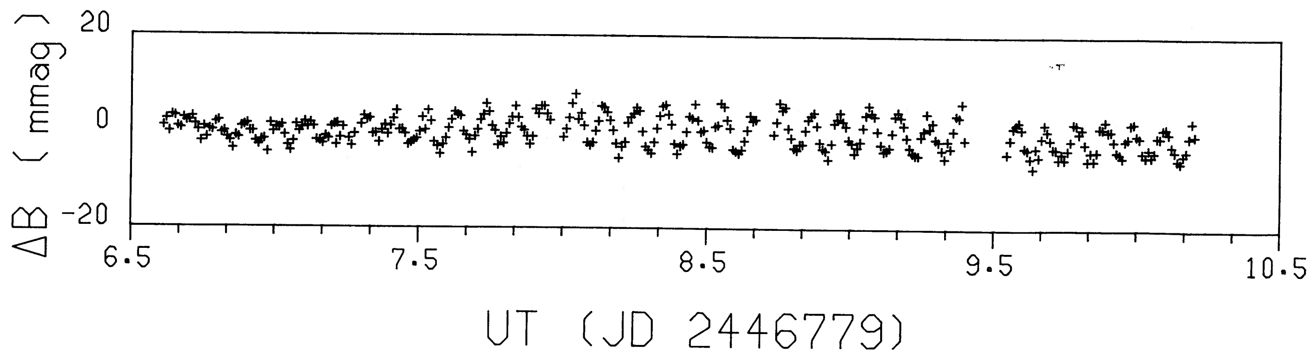

FIG. 2b

FIG. 2.—(a) Light curve of the rapid oscillations of HR 1217, observed during 1986 December 15 UT. Each cross represents an average of three consecutive 10 s integrations. (b) Same as a, for 1986 December 16 UT.

Wehlau [1985]) indicates the dominant frequencies (periods) were 5.966 minutes (10.056 hr^{-1}) on December 15 UT and 6.178 minutes (9.713 hr^{-1}) on December 16 UT. The respective peak-to-peak amplitudes of the oscillations were 1.8 and 6.8 mmag, respectively. Given the lengths of the data windows, the smallest frequency separations that can be resolved on the respective nights are 0.60 hr^{-1} and 0.25 hr^{-1}, whereas the mean spacing of the six frequencies observed by KSW and others is about 0.12 hr^{-1}. The shapes and widths of the peaks seen in our Fourier spectra are consistent with the presence of several unresolved frequencies. On the first night, the major contribution appears to be from the low-amplitude oscillation labeled $f_6 = 10.057\ \mathrm{hr}^{-1}$ in KSW. On the second, the frequencies $f_1 = 9.795\ \mathrm{hr}^{-1}$ and $f_2 = 9.550\ \mathrm{hr}^{-1}$ (again using the KSW convention) seem to have the largest, and nearly equal, amplitudes. (A Fourier spectrum of *all* of the photometric data, having much higher frequency resolution, does show the presence of these individual oscillations in the expected proportion.) The value f_1 corresponds to the period we selected to synchronize the spectroscopic exposures.

III. RESULTS AND DISCUSSION

The results for the first and second nights are compiled in Figures 3 and 4, respectively.

The upper panel (*a*) in each figure is a plot of the rapid photometry, where each point represents an average of three 10 s integrations. The light curve has been folded at the same period used to time the spectroscopic exposures and referred to the same initial phase. In both Figures 3*a* and 4*a*, the scatter in the curve is approximately 2–3 mmag. Most of this scatter is due to the modulation and gradual progression in phase of the light curve over the observation interval, arising from the presence of more than one period in the actual oscillations of HR 1217.

The middle panel (*b*) in each figure shows the relative RV shifts derived from the stellar lines in the binned spectra, as described in § II. The error bar represents one standard deviation (1 σ) for the Fahlman-Glaspey cross-correlation, which is typical for all of the points in the figure. The lower panel (*c*) gives the shifts of the Hg reference line, also expressed in terms of apparent "velocity." The error bar has the same meaning as above. The velocities plotted in Figures 3*b*, *c* and 4*b*, *c* are reproduced in Table 1.

Figures 3*c* and 4*c* are a measure of how accurately one can identify velocity variations originating in the star independent-

TABLE 1

RADIAL VELOCITY CHANGES OF HR 1217 AND Hg λ4358 REFERENCE LINE

Photometric Phase[a]	1986 DEC 15 UT RV (m s^{-1}) Star	Hg line	1986 DEC 16 UT RV (m s^{-1}) Star	Hg line
0	0	−35.0	−140.0	0
0.1............	−25.2	−21.4	77.9	−5.4
0.2............	72.9	35.8	148.7	0
0.3............	71.5	−27.5	203.9	−8.8
0.4............	−8.9	−43.9	108.6	−3.4
0.5............	27.2	−56.1	−138.6	−5.4
0.6............	30.0	18.1	−184.9	17.7
0.7............	−59.2	13.3	−189.7	24.5
0.8............	−24.5	48.8	2.3	−0.7
0.9............	−67.4	54.1	28.6	25.9
σ	76	65	50	30

[a] The phase is calculated with respect to an arbitrary epoch.

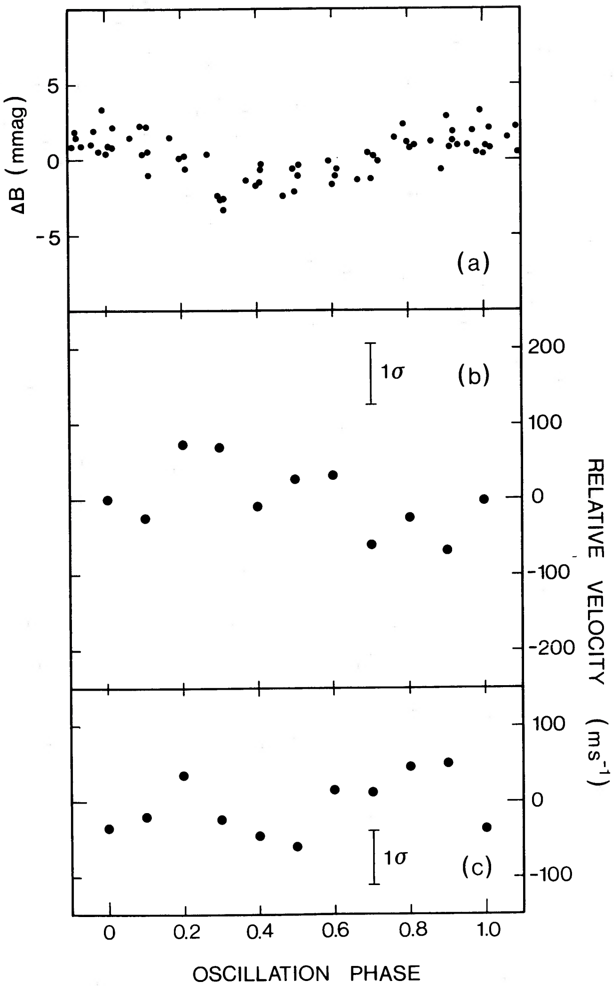

FIG. 3.—(*a*) The data of Fig. 2*a* plotted relative to the phases of the spectroscopic observations. (*b*) The RV shifts measured for the lines of HR 1217, plotted against phase of the photometric oscillation, for the night of 1986 December 15 UT. (*c*) The apparent RV shifts measured for the Hg λ4358 reference line, plotted at the same phases as for *b*.

ly from instrumental effects. These figures illustrate a clear improvement in RV precision from the first night to the next. On that first night, the derived shifts of the Hg line have a σ of $\sim$65 m s^{-1} (0.009 pixel). By the second, the total scatter had dropped to $\sim$30 m s^{-1} (0.004 pixel). The spectrograph was probably less stable on the first night because the Reticon had just been installed and the spectrograph adjusted; in addition, the improvement in telescope collimation before the second night's observations (noted in § II) may account for some of the reduction in scatter.

Despite the differences in scatter of the reference line position on the two nights, in neither case does that scatter significantly exceed 1 σ for the measurements. This indicates that there were no systematic instrumental shifts correlated with the 6.14 minute period to which the observations were synchronized, and that the Hg line shifts are a reliable gauge of the significance of any variations detected in the stellar lines.

Figures 3*b* and *c* demonstrate that, on December 15 UT, the RV variations of the star were no larger than those seen in the reference line. Therefore, we claim no detection of velocity oscillations on this night, with an upper limit of about 130 m s^{-1} ($\sim$2 σ). Note that the light amplitude of the star on this night was only about 2 mmag (Fig. 3*a* and § II*b*). By December 16 UT, however, large systematic changes in velocity are apparent in the stellar spectrum (Fig. 4*b*) which are not reflected at all in the small variations of the Hg line position. The peak-to-peak amplitude is 2 K = 400 ± 50 m s^{-1}.[5] Significantly, the amplitude of the star's photometric oscillations had increased to about 7 mmag by this time. The close agreement in phase between RV maximum and light minimum, expected for a pulsating star, helps establish the reality of the velocity curve. (See § III*b* below.)

As an additional check, the individual spectra were grouped into an arbitrary number of phase bins (seven, instead of 10) corresponding to a period of 4.288 minutes, and the analysis described in § II was repeated. No systematic velocity shifts as a function of phase were found on either night. Also, one sequence of 100 exposures spanning about an hour from the second night and having higher than average S/N was binned and analyzed separately. The same general changes in RV seen in Figure 4*b* were reproduced, but with the larger scatter expected of a smaller sample of measurements. Both tests further reinforce the validity of the measured RV curve.

[5] The "phase-smearing" effect caused by using exposures which cover 1/10 of the oscillation period is expected to reduce the derived value of 2 K by less than about 5% (Smith 1982).

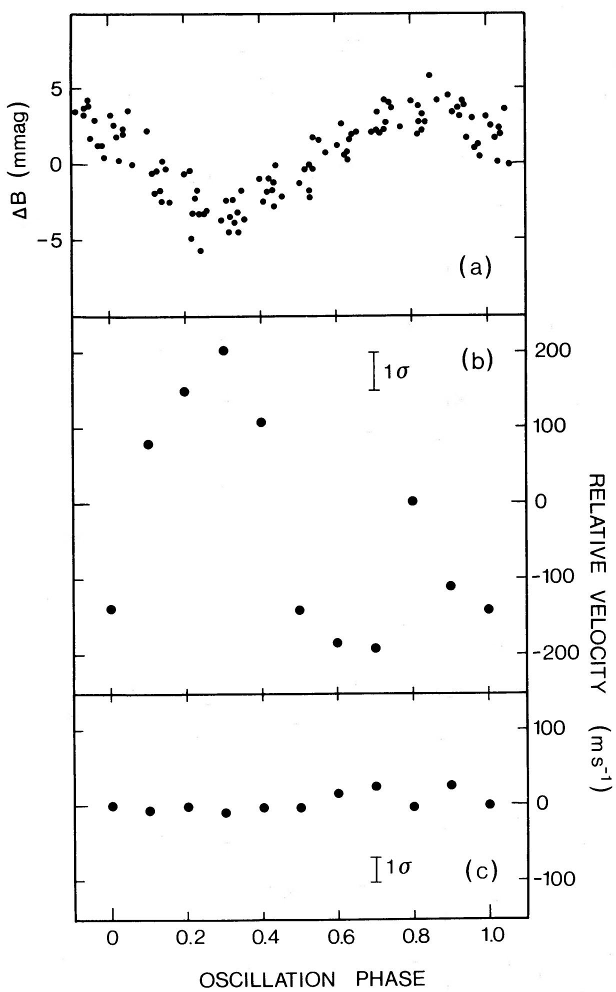

FIG. 4.—Same as Fig. 3, but for 1986 December 16 UT.

The RV curve in Figure 4*b* is difinitely not sinusoidal, but neither is the light curve in Figure 4*a*, nor is there any reason *a priori* to expect such simple curves from a suspected nonradial pulsator. There is one point in Figure 4*b*, at phase 0.8, which appears discrepant from the smoothest velocity curve one can fit to the points by eye. Similar "bumps" have been reported at the extrema of the RV curves of several δ Scuti stars (e.g., 14 Aur [Chevalier, Perrin, and Le Contel 1968] and γ Boo [Auvergne, Le Contel, and Baglin 1979]), although the evidence for them is not strong.

The detection of an RV oscillation in HR 1217 confirms the status of roAp stars as pulsating variables. It also allows us to address the other two questions posed in the Introduction.

a) RV Variability as a Test of the Oblique Pulsator Model

The oblique pulsator model (§ I) predicts that the velocity amplitude should vary in phase with the light amplitude. HR 1217 was observed as its light amplitude was increasing to a maximum, which occurred later on December 16 UT (according to rapid photometry collected for a week following the CFHT run). The RV amplitude was clearly modulated in the same sense, increasing from an upper limit of 150 m s^{-1} to 400 m s^{-1} in just one day. This behavior is in complete agreement with the oblique pulsator hypothesis.

b) RV-to-Light Amplitude Ratio and Phase Lag

The value of 2 K/Δm_B derived from the data in Figures 4*a* and *b* is 59 ± 12 km s^{-1} mag^{-1}. If this value is applied to the photometric amplitude observed on the first night, one derives an expected velocity amplitude of 2 K $\approx 106 \pm 46$. This is consistent with the upper limit of ~ 130 m s^{-1} established by our observations on that night.

Because rapid multicolor measurements were not possible with the photometer used in this program, we have no direct determination of 2 K/Δm_V. However, five-color photometry of HR 1217 by Schneider (cf. Weiss 1986) and multibandpass observations of other roAp stars (e.g., Weiss and Schneider 1984) indicate that Δm_B tends to be approximately twice Δm_V for these variables. That leads to a rough estimate for 2 K/Δm_V of $\sim 120 \pm 25$ km s^{-1} mag^{-1}.

Surprisingly, our estimates of 2 K/Δm are similar to the values found for δ Scuti stars considered to be *radial* pulsators (e.g., Leung and Wehlau 1967; Smith 1982), and about twice what is expected for the nonradial candidates. Yet all other evidence appears to point to the nonradial nature of the roAp pulsations. One explanation of this seeming contradiction is that the variations of the roAp and δ Scuti stars are unrelated to one another, and any direct comparison is invalid. However, there is another possibility.

KSW, by comparing the magnetic field strength variations of HR 1217 with its light amplitude modulation in the context of the oblique pulsator model, have tentatively identified the star's two dominant oscillation frequencies (f_1 and f_2) as $l = 1$ modes. They also constrain the inclination and obliquity of the star to be $i \geq 20°$ and $\beta \leq 50°$. If $i \approx \beta$, then when the observed magnetic field reaches its maximum value, one magnetic pole of the star will be at or near the subsolar point on the stellar disk. If the star is also an oblique pulsator, one of the pulsation poles will be located at the same point. In such an orientation, an $(l, m) = (1, 0)$ pulsator will resemble an $l = 0$ pulsator. In other words, close to phases of maximum oscillation amplitude (such as during the second night of our run), a nonradial pulsation in HR 1217 could conceivably masquerade as a radial mode in terms of relative RV and light amplitudes.

On the other hand, the phase lag between the RV and light curves should be relatively insensitive to the above effect. Unfortunately, this parameter is also not very sensitive in distinguishing nonradial from radial pulsators among the δ Scuti stars (Balona and Stobie 1979; Smith 1982). Our best estimate of the phase lag between RV maximum and light minimum is $\Delta\Phi = 0.045 \pm 0.005$. This is based on spline fits to the RV and photometric data plotted in Figures 4*a* and *b*; our value of $\Delta\Phi$ is consistent with published values for δ Scuti variables, which tend to fall in the range $\sim$0.05–0.1 (e.g., Smith 1982). Although the value of $\Delta\Phi$ derived here is based on *B* photometry alone, earlier multicolor photometry of HR 1217 (cf. Weiss 1986) revealed no significant phase difference between its dominant *B* and *V* oscillations.

In summary, this first detection of a rapid RV oscillation in one of the roAp stars has several immediate implications.

1. It definitely establishes the roAp stars as pulsating variables.

2. The modulation of RV amplitude in the same sense as the photometric amplitude agrees with the prediction of the oblique pulsator hypothesis.

3. It provides the first estimates of 2 K/Δm_B and phase lag for the class of roAp stars. At present, these values do not clearly confirm or deny a link between the pulsations of the roAp and δ Scuti stars, in part because of an ambiguity which may arise from a coincidence of the inclination and obliquity of HR 1217. Further RV observations of other roAp stars, presumably having different *i* and β than HR 1217, could resolve this ambiguity.

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