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ABUNDANCE AND ISOTOPIC COMPOSITION OF PLATINUM IN χ LUPI AND HR 7775 DERIVED WITH THE HELP OF NEW LABORATORY SPECTRA OF Pt II[1]

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ABSTRACT

The platinum isotope anomaly observed in the chemically peculiar HgMn star χ Lupi has been confirmed by analysis with new high-resolution laboratory spectra recorded with the VUV Fourier transform spectrometer at Lund University. The χ Lupi platinum composition is shown to be a mixture of isotopes 196 and 198. Recent observations made with the *Hubble Space Telescope* Goddard High-Resolution Spectrograph (*HST*/GHRS) of a similar temperature HgMn star, HR 7775, have also been analyzed; these show that line profiles of Pt II are best fitted by the terrestrial isotopic mixture. Fits of synthetic spectra to the observations yield a logarithmic abundance of platinum of $\log N_{\rm Pt} = +6.05$ for χ Lupi and $\log N_{\rm Pt} = +6.50$ for HR 7775, on a scale of $\log N_{\rm H} = +12.00$.

Subject headings: stars: abundances — stars: chemically peculiar — stars: individual (HR 7775) — stars: individual (χ Lupi)

1. INTRODUCTION

Observations of platinum lines in astronomical spectra have been essentially limited to warm, chemically peculiar stars of the HgMn and classical magnetic peculiarity types, where platinum abundances implied from the great line depths can be several orders of magnitude greater than the solar abundance. Platinum has not been observed in solar-composition stars, and its presence in the solar spectrum has only been detected at trace amounts through synthetic spectrum modeling of a few Pt I lines (Burger & Aller 1975) found at near-ultraviolet wavelengths. Neutral platinum has also been recently detected in a Population II star (Cowan et al. 1996).

For chemically peculiar stars, the first identifications of platinum put forward in the literature are those of Dworetsky (1969). Of particular interest was the discovery of a wavelength shift for the Pt II λ4046 Å transition, found first for χ Lupi (Dworetsky 1969) and later for several other mercury-rich stars that also exhibited wavelength shifts for the centroid of the Hg II λ3984 Å transition (Dworetsky & Vaughn 1973). These wavelength shifts have been interpreted as isotope shifts, and represent a key constraint on any theory attempting to explain the nature of these stars. The theory of diffusive segregation, as applied to chemically peculiar stars by Michaud, Reeves, & Charland (1974), offers a mechanism for anomalies in both abundances and isotopic composition. The theory has, as yet, not been directly applied to the case of platinum.

The ultraviolet spectral region is rich in spectral lines of ionized platinum, to such an extent that Pt II is employed as the wavelength calibration standard on space-based instruments. For late B-type chemically peculiar stars, Pt II represents the dominant ionization stage, and its strongest lines have been detected at ultraviolet wavelengths in the spectra of chemically peculiar stars observed with the *International Ultraviolet Explorer* (*IUE*) satellite (see for example Dworetsky, Storey, & Jacobs 1984). However, due to the limited spectral resolution of the *IUE* data, it is not possible to study the isotopic composition.

The high spectral resolution of GHRS onboard *HST* makes it possible to investigate the isotopic composition in sharp-lined stars. The χ Lupi Pathfinder Project (Leckrone et al. 1997) has been addressing the issues of abundances and isotopic composition for this sharp-lined HgMn star. Isotopic composition analyzes for mercury (Leckrone, Wahlgren, & Johansson 1991) and thallium (Leckrone et al. 1996) provide evidence that only the heaviest isotope is present. The optical work of Dworetsky & Vaughn (1973) for this star suggested that the isotopic composition for platinum is weighted toward the heaviest isotopes, but they were not definitive about the mixture.

In order to better define the platinum isotope mixture in χ Lupi, we have compared the line profiles of four Pt II lines

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in echelle-mode GHRS spectra with those of laboratory spectra. We are able to show that the derived isotopic composition reflects a mixture of the heaviest two isotopes, in contrast to the results for mercury and thallium. As a further test of the diffusion paradigm, we have also analyzed two Pt II lines in GHRS spectra of the sharp-lined HgMn star HR 7775. We find that although these two stars exhibit similar effective temperatures and platinum abundance enhancements, their Pt^+ isotopic compositions are markedly different.

2. LABORATORY WORK

High-resolution laboratory spectra of Pt II from hollow cathode lamps have been recorded from 1800 to 3000 Å at a resolution of 0.025 cm^{-1} (resolving power 2×10^6 at 2000 Å) with the VUV Fourier Transform (FT) spectrometer at Lund University. The short-wavelength limit is imposed by the transmission qualities of the fused-silica beam splitter. The high-resolution GHRS spectra of χ Lupi are all in the UV region, which creates a problem in that the precision with which a transition isotope shift (TIS) can be measured is diminished in the UV due to Doppler broadening. (The shift within an energy level is referred to as isotope shift (IS) and that in a transition between shifted energy levels is referred to as transition isotope shift.)

The Doppler width, $\Delta\nu_D$, can be reduced by a cooling of the light source, as $\Delta\nu_D \propto T^{1/2}$; hollow cathode lamps are often cooled with water or liquid nitrogen. The temperature of the radiating atoms is, however, always higher than that of the walls of the lamp.

In order to achieve a resolved TIS and as strong a Pt II spectrum as possible, different setups of continuously pumped hollow cathode light sources were tested in the experiment. In a hollow cathode light source, at a suitable current and pressure, the discharge is concentrated in the hole of the cathode, and material from the walls is sputtered into the discharge and excited. A choice of carrier gas from among the inert gases, or a mixture of them, allows the sputtering and the excitation of the metal atoms to be varied. For a given cathode material, diameter, and carrier gas, the properties of the discharge are determined by voltage, discharge current, and pressure. These parameters influence each other and cannot be varied independently.

One of the light sources, a cathode of platinum foil of thickness 0.1 mm inserted into a cylindrical tube of nickel 30 mm long and 20 mm wide, was cooled with liquid nitrogen. Several FT spectra were recorded using a current of 120 mA with a neon gas pressure of 1.0 torr. A second light source, a hollow cathode of platinum inserted into a cylindrical tube of nickel 45 mm long and 7 mm wide, was cooled with water. Series of spectra were obtained using a variety of carrier gas mixtures, such as helium, argon, and neon, at a maximum pressure of 2.0 torr. The current was varied from 100 to 400 mA. A third and last light source, an uncooled commercial Ne-Pt hollow cathode lamp manufactured by Imaging and Sensing Technology Corporation, was run at 20 mA, the maximum current recommended. The different FT runs contained up to 60 scans each.

The Pt II spectrum obtained with the light source cooled with liquid nitrogen showed the best resolved TIS. Although the higher currents in the water-cooled lamp produced the strongest Pt II spectra, the greater Doppler broadening made these spectra unsuitable for analysis of isotope shifts. Only the spectra from the light source cooled with liquid nitrogen were of good enough quality to be used in our analysis (see Fig. 1).

The spectra were reduced using the DECOMP package (Brault & Abrams 1989), and the Pt II lines were identified using the line list of Reader et al. (1988). The wavenumber scale obtained directly from a FT spectrometer is set by the He-Ne sampling laser and is linear to within the stability of this laser, $1:10^8$. However, because of the nonparallellism between the laser and the light beam, further calibration is needed in order to establish an accurate wavenumber scale. In principle, only one calibration line is needed, but in practice many lines are chosen. The averaged quantity $\langle \Delta\sigma/\sigma \rangle$, where σ is the vacuum wavenumber and $\Delta\sigma = \sigma_{ref} - \sigma_{measured}$, yields the calibration offset. Typically, this constant differs from unity by $1:10^6$ for the FT spectrometer at Lund University. To set the absolute wavelengths on a scale consistent with other spectra, we used for calibration the Ni II lines that appeared in the spectrum; these have previously been measured relative to Fe I secondary standards in spectra emitted from a hollow cathode made of stainless steel (Litzén, Brault, & Thorne 1993).

It has been shown (Brault & Abrams 1989) that the accuracy with which the position of a line can be measured is given by the full width at half-maximum (FWHM) of the line profile, specified in units of mK, divided by $n^{1/2}$ times the signal-to-noise ratio, where n is the number of indepen-

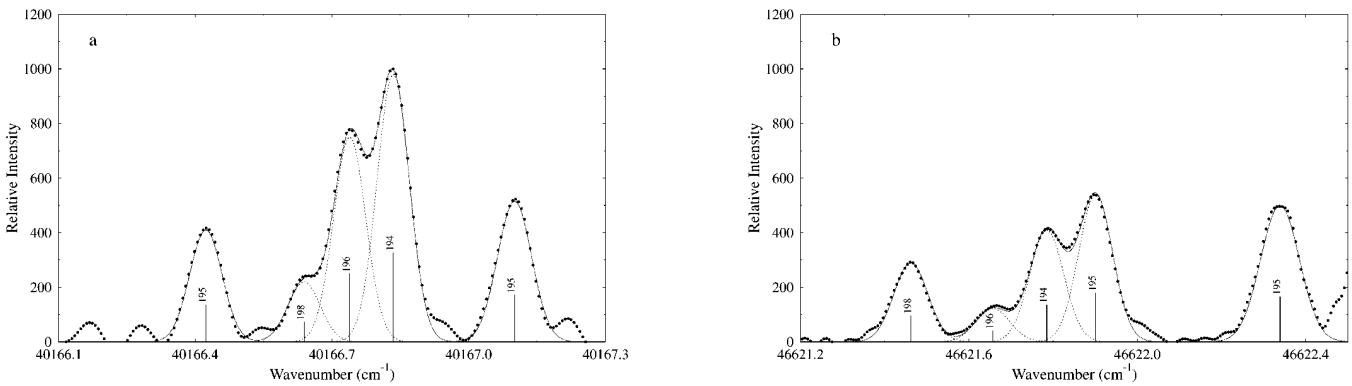

FIG. 1.—Structure of the laboratory (*a*) 40166 cm^{-1} and (*b*) 46621 cm^{-1} lines, with peak assignments. Solid line shows the best overall computed line profile to the observed structure (*dots*). Dashed lines show the best computed line profile to each individual component. Vertical bars are at the location of each major component of the pattern.

dent spectral points in the line width. The observed FWHM for the Pt II lines of interest is about 100 mK, while the S/N ratio ranges from approximately 1000 for strong lines down to 100 for the weakest. Considering the summed uncertainty of the determination of line positions and the wavenumber calibration, a conservative estimate of the wavenumber uncertainty is $\pm$ 10 mK at 50,000 cm^{-1}, which corresponds to $\pm$ 0.5 mÅ at 2000 Å for strong lines.

3. ISOTOPIC AND HYPERFINE STRUCTURE ANALYSIS OF THE LABORATORY SPECTRA

The spectrum of singly ionized platinum, Pt II, has a ground state at $5d^9\ ^2D$. The Pt II spectrum was first investigated by Shenstone (1938), who classified more than 550 lines. Sansonetti et al. (1992) remeasured the spectrum and determined wavelengths and intensities for about 5600 lines in the region of 1130–4330 Å using vacuum ultraviolet (VUV) grating measurements together with very accurate Fourier transform spectrometry measurements from Engleman (1985). Blaise & Wyart (1992) extended the term analysis with 43 new even levels and 104 new odd levels by using the wavelength measurements from Sansonetti et al. (1992). A laboratory analysis by Engleman (1989) has determined the transition isotope shifts between ^{194}Pt, ^{195}Pt, and ^{196}Pt, and the hyperfine splitting (hfs) for ^{195}Pt for a number of Pt II lines in the visible and near-ultraviolet spectra. Baird & Stacey (1974) measured isotope shifts in three Pt II lines in the visible region and deduced the relative shifts from the line they measured most accurately.

Platinum has six stable isotopes, with mass numbers 190, 192, 194, 195, 196, and 198. The structure of a platinum transition is thus determined by the TIS for the five even isotopes and the isotopic and hfs of the single odd isotope. The relative contributions of ^{190}Pt and ^{192}Pt are too low (less than 1%) to have any observable effect on the profile of the observed laboratory Pt II transitions. The distribution of the isotopes are 0.01% (^{190}Pt), 0.78% (^{192}Pt), 32.9% (^{194}Pt), 33.8% (^{195}Pt), 25.3% (^{196}Pt), and 7.21% (^{198}Pt). Since $J \neq 0$, having $F = J + \frac{1}{2}$ and $F = J - \frac{1}{2}$, the nuclear spin $I = \frac{1}{2}$ of the odd isotope splits each level into two hyperfine levels. Each line of the ^{195}Pt isotope thus has either three or four components, depending on the value of ΔJ, two of which dominate in intensity (Kuhn 1962). The weaker components were not seen in the present study.

The isotopic shift consists of two parts, the mass shift and the field shift. The mass shift decreases with $1/M^2$ and is insignificantly small in an element as heavy as platinum (King 1984). The field shift arises from the energy level dependence upon the electric charge distribution within the nuclear region, which is affected by the number of neutrons. In general, only terms involving *s*-electrons, which have a finite probability of being in the nuclear region, show isotope shifts, so the largest TISs involve a change in the number of *s*-electrons. Smaller shifts can, however, result from transitions involving changes in screening of *s*-electrons.

The Pt II transitions of interest in our laboratory spectra were those that had a well-resolved TIS and that had also been observed in the stellar spectra of χ Lupi and HR 7775. The isotope shift ratio $(\sigma^{194}-\sigma^{198})/(\sigma^{194}-\sigma^{196})$ is determined by the nuclear structure and is independent of the particular transition or the stage of ionization (King 1984). It can be evaluated from the best resolved lines in the laboratory spectra and used to calculate the position of the weak ^{198}Pt component in lines in which only the ^{194}Pt and ^{196}Pt components are resolved. In general, the two strong ^{195}Pt components lie outside the group of even isotopes. Only five lines in the laboratory Pt II spectra showed a large enough TIS that they could be used to determine the isotope shift ratio. Four lines are transitions between the $5d^8 6s$ and $5d^8 6p$ configurations, whereas the fifth line is a transition between $5d^7 6s^2$ and $5d^7 6s 6p$ (Blaise & Wyart 1992). The corresponding transitions involve a change in the number of *s*-electrons, as expected from theory.

In order to fit line profiles to the observed structure in the laboratory Pt II lines, all isotopic and hyperfine components were assumed to be Gaussian in shape and to possess the same FWHM. The relative intensities of the various components were defined by the terrestrial isotopic abundances and by the theoretical intensity ratios within hyperfine multiplets. The only parameters allowed to vary were the positions of the individual components, which were derived from a least-squares fit to the observed pattern (Fig. 1). The same procedure was followed for each of the five lines.

The resulting isotope shift ratios agree well with the results of Baird & Stacey (1974) and LaBelle et al. (1989) (see Table 1). The scatter amounts to an uncertainty of $\pm$ 0.1 mÅ in the determination of the position of the ^{198}Pt isotope component. For the stellar analysis this accuracy is sufficient, since the relative wavelength scale of a GHRS spectrum in the echelle mode has been shown to have an uncertainty of $\pm$1 mÅ.

4. STELLAR SPECTRUM SYNTHESIS AND ABUNDANCE ANALYSIS

We have applied a synthetic spectrum approach to the investigation of the platinum abundances and isotopic mixtures in the sharp-lined HgMn stars χ Lupi (B9.5p

TABLE 1

MEASURED ISOTOPE SHIFT RATIOS IN Pt II

Transition[a] (cm^{-1})	Wavenumber[b] (cm^{-1})	Isotope shift ratio (Å)	Average	Other Work
4786–53875.....	49088.8797	2.066	...	...
9356–57018.....	47661.9296	2.107	...	...
4786–51408.....	46621.7836	2.102	2.086	2.085[c]
23876–65587.....	41711.6583	2.084	...	2.085[d]
24879–65046.....	40166.6948	2.071	...	...

[a] Transitions denoted by lower and upper energy levels.
[b] Center of gravity wavenumbers.
[c] Baird & Stacey (1974).
[d] LaBelle et al. (1989).

TABLE 2

WAVELENGTHS (Å) FOR THE ISOTOPE AND HYPERFINE COMPONENTS OF Pt II TRANSITIONS

Transition[a]	*gf*-value	194	195A[b]	195B	196	198
13329–64757.....	0.294	1944.460[c]	1944.469[c]	1944.452[c]	1944.465[c]	1944.469[c]
4786–51408.....	1.318	2144.244	2144.224	2144.264	2144.249	2144.255
15791–61190.....	0.126	2202.015	2202.010	2202.025	2202.019	2202.024
23461–64757.....	0.742	2420.812	2420.825	2420.800	2420.818	2420.825

[a] Energy levels in the transitions are represented by their energy values in cm^{-1}.
[b] Strongest hyperfine component.
[c] Vacuum wavelength.

HgMn + A2Vm) and HR 7775 (B9p HgMn). The high degree of spectral line blending found at UV wavelengths for B- and A-type stars, even for spectra obtained under conditions of high resolution, makes line centroid measurements uncertain if one does not attempt to account for opacity contributions from blended transitions. We acknowledge that the possible presence of unidentified spectral lines may affect our results, but we are confident that the use of several spectral lines and a comparison between two stars of similar effective temperature and chemical peculiarity class will diminish this concern.

The spectral observations for both stars utilize the echelle mode of the GHRS, typified by spectral resolutions $\lambda/\Delta\lambda$ of between 80000 and 95000 and S/N ratios of 70–100 at the continuum level. The recording and reduction of the observational data of χ Lupi has been discussed at length by Wahlgren et al. (1995). The more recently obtained spectra of HR 7775, for GTO programs 6245 (Leckrone) and 6275 (Brandt), were treated in a similar manner and will be detailed in a forthcoming publication.

For χ Lupi, the computations of the LTE theoretical spectra utilized homogenous, plane-parallel, line-blanketed model atmospheres calculated with the ATLAS8 code (Kurucz 1979) for both χ Lupi A ($T_{\rm eff} = 10{,}650$ K, log $g = 3.8$, $v_t = 0.0$ km s^{-1}) and χ Lupi B ($T_{\rm eff} = 9200$ K, log $g = 4.2$, $v_t = 2.4$ km s^{-1}) (Wahlgren, Adelman, & Robinson 1994). Synthetic spectra were calculated for each stellar component with the program SYNTHE (Kurucz & Avrett 1981) and combined in accordance with their light ratios 6.6, 6.3, 6.2, and 6.0 at $\lambda\lambda$1944, 2144, 2202, and 2420 Å, respectively. The primary and secondary star spectra were offset in wavelength according to the ephemeris of Dworetsky (1972). The spectral synthesis techniques are as described by Leckrone et al. (1991) and the spectrum normalization routine by Wahlgren (1996). For HR 7775, an ATLAS9 model atmosphere defined by $T_{\rm eff} = 10{,}700$ K, log $g = 4.0$, $v_t = 0.0$, and $v \sin i = 2.0$ km s^{-1} has been used (Wahlgren et al., in preparation). HR 7775 has previously been studied at optical (Adelman 1994) and UV (Smith & Dworetsky 1993) wavelengths for its atmospheric parameters and elemental abundances.

Atomic data for general line-blending calculations were taken from the Kurucz (1991) database. The experimentally determined wavelengths for the Pt II lines have been incorporated into this atomic data base. The *gf*-values for the Pt II lines were recently calculated by Wyart, Blaise, & Joshi (1995). These *gf*-values have been scaled by means of lifetime measurements by Larsson, Zerne, & Lundberg (1996). The four lines chosen for the laboratory comparison, at 1944, 2144, 2202, and 2420 Å, are presented in Table 2. They correspond to transitions between the energy levels given in the first column, which involve the configurations $5d^8 6p$ and $5d^8 6s$ (Blaise & Wyart 1992). The position of the ^{198}Pt component has been calculated from the resolved 194 and 196 components and the isotope shift ratio discussed above. Table 2 gives the positions of all isotope and hyperfine components in these four lines.

The different spectral intervals in χ Lupi containing the four Pt II lines in Table 2 have all been wavelength calibrated by means of lines of the iron-group elements common to FT laboratory and stellar spectra, having an accuracy of better than 0.3 mÅ. For all lines, the difference between the laboratory and stellar spectra is less than 1 mÅ. The general procedure for establishing the GHRS absolute wavelength scale is described by Leckrone et al. (1993).

The Pt II stellar lines at $\lambda\lambda$ 2144 and 2420 Å are blended with other lines and have been included in this analysis mainly as a test of the result obtained from the $\lambda\lambda$1944 and 2202 Å lines. These last two are slightly blended with a Fe II line and a weak Cr II feature, respectively. Changing the *gf*-value of the unclassified Fe II line at 1944.512 Å to the extent that it becomes saturated does not affect the synthesized Pt II feature at λ 1944 Å. The same holds for the Cr II line at 2202.040 Å. The measured center of gravity wavelengths of the stellar lines are presented in Table 3. We have not included the Pt II line at 2144 Å in the measurements since it is heavily blended with Pt I. The measured centroids of the stellar lines are all redshifted relative to those of the laboratory platinum lines. However, none of the measured stellar wavelengths agree with the wavelengths of transitions for pure ^{198}Pt (Table 2). The stellar feature at 2202 Å seems to agree well with pure ^{198}Pt, but the center of gravity wavelength is redshifted as a result of blending with a Cr II line at 2202.040 Å.

The observed Pt II features in χ Lupi have all been synthesized with platinum isotopic mixtures ranging from monoisotopic $^{198}Pt^+$ to the terrestrial isotopic mixture. Initial attempts to synthesize the observed features with the isotopes blended in terrestrial proportions provided an unsatisfactory match to the observations (Fig. 2), the syn-

TABLE 3

CENTER OF GRAVITY WAVELENGTHS (Å) FOR Pt II LINES FROM LABORATORY AND STARS

Laboratory[a]	χ Lupi[b]	HR 7775[b]
1944.4637[c].....	1944.468[c]	1944.464[c]
2202.0163	2202.025	...
2420.8159	2420.826	...

[a] The wavelength uncertainty is ± 0.5 mÅ for all laboratory lines.
[b] The wavelength uncertainty is ± 1 mÅ for all stellar lines.
[c] Vacuum wavelength.

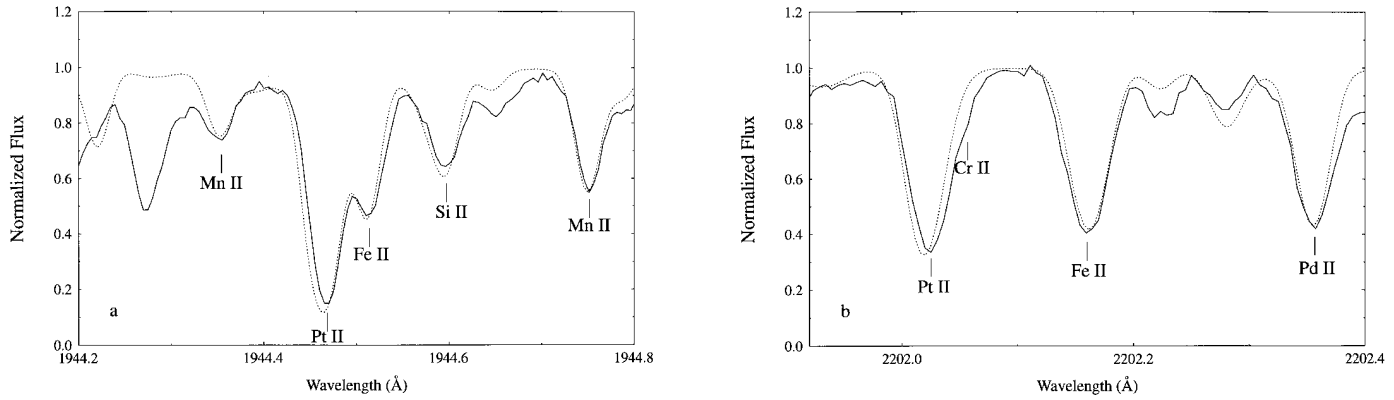

FIG. 2.—Observed spectra of χ Lupi (*solid line*) compared to synthetic spectra, calculated with a terrestrial isotope mixture of platinum (*dashed line*). The match between observed and computed line profiles is unsatisfactory; the calculated line profile is clearly blueshifted.

thesized lines being blueshifted relative to the observed stellar features. Decreasing the Pt II abundance does not improve the fit. All attempts to include the ^{195}Pt isotope in the synthesis resulted in a broadening of the synthetic line profile compared to the observed profile. If it is assumed that the isotope mixture matches that of pure $^{198}Pt^{+}$, as suggested by Dworetsky & Vaughn (1973), the synthesized platinum lines are found to be slightly redshifted (Fig. 3). A mixture of ^{196}Pt and ^{198}Pt provided the best fit of the calculated features to all observations (Fig. 4). The optimum proportions of these two isotopes cannot be exactly determined, partly because of the line blending and partly because of the limited accuracy with which a stellar feature can be modeled. A mixture of the two heaviest isotopes, including a contribution of ^{194}Pt to an amount as low as 5%, still shifted the synthetic profile toward the blue com-

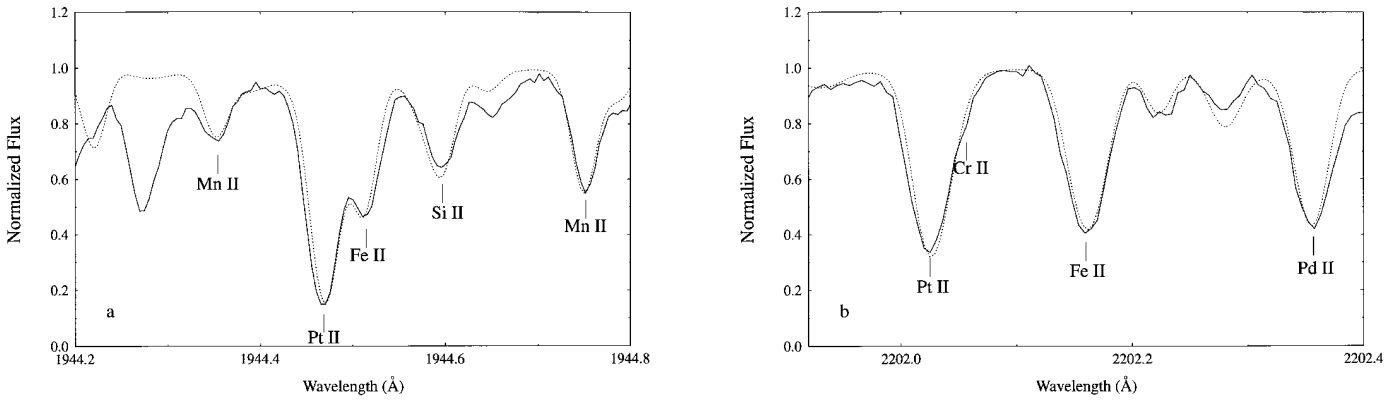

FIG. 3.—Observed spectra of χ Lupi (*solid line*) compared to a synthetic spectra, calculated with monoisotopic ^{198}Pt (*dashed line*). The match between observed and computed line profiles is unsatisfactory. The calculated line profiles are shifted toward a longer wavelength than observed.

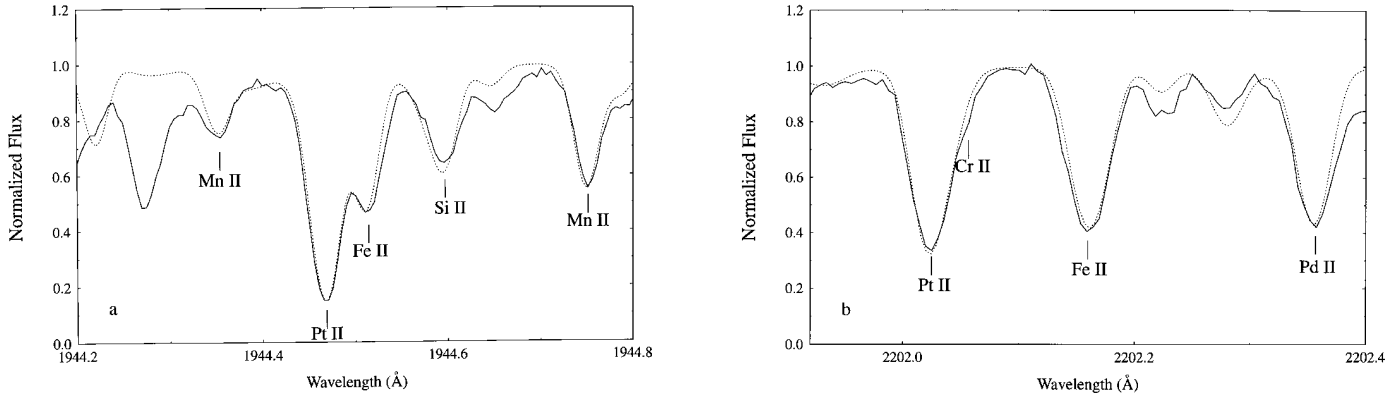

FIG. 4.—Observed spectra of χ Lupi (*solid line*) compared to a synthetic spectra, with a mixture of ^{196}Pt and ^{198}Pt (*dashed line*). The mixtures in the different wavelengths regions are slightly different: (*a*) and (*b*) show a mixture of 70% ^{196}Pt and 30% ^{198}Pt, while (*c*) and (*d*) show a 50%:50% mixture of the two heaviest isotopes.

pared to the observed one. A smaller amount of ^{194}Pt did not significantly affect the calculated profile, but does not fill in the observed profile either.

The mixture of approximately 70% ^{196}Pt and 30% ^{198}Pt illustrated in Figure 4 provides the best fit to the stellar lines, but all ratios from 70%:30% to 50%:50% show a reasonably good fit. Thus, we can only derive upper and lower limits for the ratio of the two heavy isotopes ^{196}Pt:^{198}Pt in the platinum mixture in χ Lupi; approximately 70%:30% for the upper limit and 50%:50% for the lower. The Pt II lines λλ2144 and 2420 Å confirm the adopted ^{196}Pt and ^{198}Pt mixture but do not further narrow the limits.

The spectral intervals in HR 7775 containing the two Pt II lines λλ1944 and 2144 Å have been wavelength calibrated using the same lines and method as used for χ Lupi. Comparisons of these two lines show that the isotopic mixture of Pt^+ is different (Fig. 5) in the two stars. The centroid of the 1944 Å line is measured to be 1944.464 Å (Table 3), which agrees well with the center of gravity measurement of the laboratory platinum line. Synthetic spectra for both lines in HR 7775 have been calculated with three isotopic mixtures of ^{196}Pt:^{198}Pt—a terrestrial ratio (78%:22%), a ratio of 50%:50%, and pure ^{198}Pt (Fig. 6). The result favors a terrestrial Pt II mixture in HR 7775, in contrast to the anomalous mixture in χ Lupi.

As part of the analysis, the abundance of platinum, based on the Pt II lines λλ1944, 2202, and 2144 Å, is found to be log $N_{Pt} = +6.05$, on a scale where log $N_H = 12.00$. This may be compared with the result of +6.0 (Dworetsky, Storey, & Jacobs 1984), based on λλ1777 and 2144 Å and +5.85 (Wahlgren et al. 1995) from the 2144 Å transition. Neither of these previous studies included the effects of line desaturation through isotopic and hyperfine structure for Pt II. But we must also caution that abundances derived from different transitions within an ionization state may not provide the same results in the absence of LTE. This point will require further investigation. The abundance of platinum in HR 7775 is determined to be log $N_{Pt}) = +6.50$, i.e., even more overabundant than in χ Lupi.

5. CONCLUSIONS

By assuming a constant ratio between the transition isotope shifts of the most abundant Pt isotopes measured from five laboratory lines, it has been possible to derive the position of the unobserved ^{198}Pt in four other Pt II lines, which are of interest for the study of platinum in χ Lupi. We present accurate wavelengths of the four most abundant isotopes for the investigated lines.

The reality of the platinum isotope anomaly previously observed in χ Lupi is beyond question, but we conclude that there is a mixture of the isotopes ^{196}Pt and ^{198}Pt. To

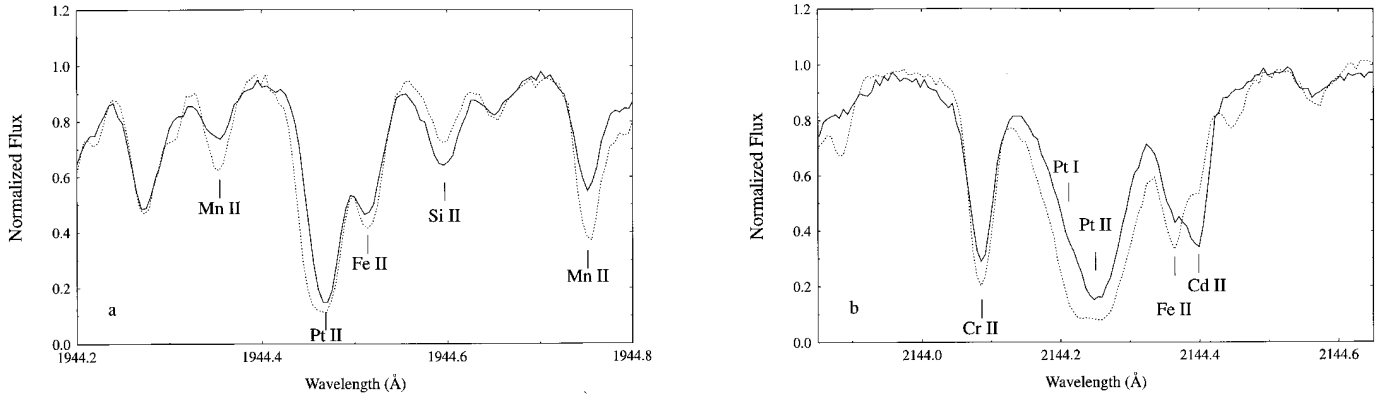

FIG. 5.—Comparison of the 1944 and 2144 Å Pt lines in χ Lupi (*solid line*) and HR 7775 (*dashed line*). The platinum lines in HR 7775 are shifted to a shorter wavelength, which implies a different isotopic mixture as compared to the platinum lines in χ Lupi.

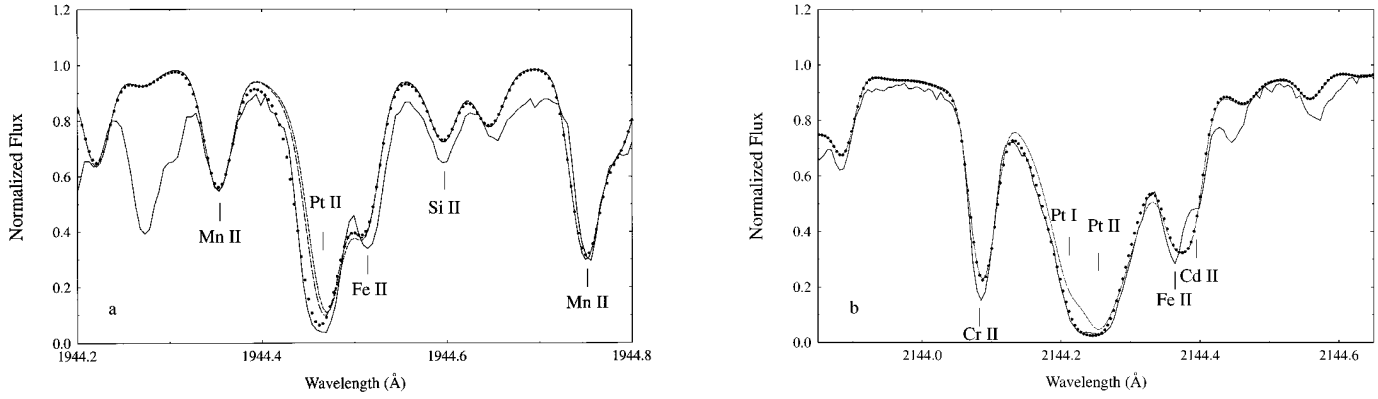

FIG. 6.—Observed spectra of HR 7775 (*solid line*) compared to synthetic spectra. *Dotted lines*: calculations for a terrestrial platinum mixture. *Long-dashed lines*: calculations for a 50%:50% mixture of ^{196}Pt and ^{198}Pt. *Short dashed lines*: calculations for monoisotopic ^{198}Pt. The result favors a terrestrial Pt II mixture.

further pursue a more exact abundance ratio between the two heaviest platinum isotopes in χ Lupi, it may be necessary to study platinum lines in high-resolution spectra at optical wavelengths, where the wavelength separations between the isotopic components are larger.

The isotopic composition of Pt^+ in HR 7775 agrees very well with the terrestrial composition. Both stars are overabundant in platinum with a factor of 10^4 to 10^5compared to the solar value.

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