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GRAZING INCIDENCE SPECTRA OF HIGHLY IONIZED OXYGEN IN A THETA-PINCH

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The application of a grazing incidence spectrometer to the analysis of line emission from a Theta-pinch plasma in deuterium, 'seeded' with a few percent of the rare gases, has revealed new spectra of highly-stripped ions (Fawcett, 1964). Using the same 2 metre spectrometer and the MAGGI I plasma source as described in reference 1, lines of OVI and OVII have been recorded down to 17 Å. Over the wavelength range from 184 Å to about 70 Å the optical transitions of these ions are from higher levels to the $n = 2$ principle quantum level. Some of these spectra have not previously been observed and it is the purpose of this note to identify the newly observed emission lines.

Previous observations of the HeI isoelectronic sequence by Edlen (1952) include the longest wavelength members of the 1s 2p - 1s nd and the 1s 2s - 1s np series of OVII, i.e. n = 3. The 1s 2s - 1s 2p transitions predicted by Edlen have also been observed (Gabriel 1962). In addition, the ionization limit for OVII is well established from the resonance line transitions measured by Tyren (1940).

For the OVI ion, spectra in this wavelength region are tabulated in 'Ultra-violet Emission Lines' by R.L. Kelly (1959) while the ionization limit and ns^2S, np^2P, nd^2D etc. term values with n up to 8 have been established by Edlen's (1934) work. Recent measurements by Bockasten et al (1963) of the upper level transitions of OVI Eq. 7g-8h, 6f-7g etc., have demonstrated that the hydrogen-like terms of OVI can be calculated to a high degree of accuracy using the polarization formula given by Edlen (1964).

In the present analysis, the revised term values up to n = 8, calculated by Bockasten (unpublished) using the polarization formulae, were employed as wave-length standards. A cubic equation computed for the dispersion curve on a least squares fit to the above standard wavelengths (Edlen 1952, 1964) predicted the observed lines with a standard deviation of 0.045 Å. The wavelengths of the spectral lines measured by interpolation on the cubic as shown in Table I are estimated to be accurate to ± 0.05 Å.

A reproduction of the emission spectrum of the MAGGI I Theta-pinch is shown in Fig.1 over a wavelength range from 200 Å to 70 Å. The exposure was intensity-integrated over 30 discharges with an initial gas filling of 0.1 Torr deuterium + 5% oxygen. Most of the spectral lines in Fig.1 can be assigned to OIV, OV, OVI and OVII, with wall impurities from the Al_2O_3 tube such as S, Al, C also appearing.

For OVI, the 2p - nd and 2p - ns series both having a common limit at 98.318 Å and the 2s - np series with a limit at 89.766 Å, were well developed. Up to 12 members of the 2p - nd series and 8 members of the 2s - np series were observed. In the triplet series of OVII, observations extended to n = 7 for the 1s 2p - 1s nd transitions and n = 5 for 1s 2s - 1s np. The relative intensities of the spectral lines were read directly from a microphotometer trace of the spectrum and are shown in Table I.

The wavelengths measured at the peak intensity of the lines are identified with the strongest transition in each multiplet as shown in Table I. For OVI, the 2p and 2s term values are known and the upper series member can be predicted by a Ritz formula given by

$$T_n = T_\infty - \frac{R'}{n^{*2}} ,$$

where $n^* = n - \delta n$ is the effective quantum number and δn is the quantum defect. For the non-penetrating orbits, the polarization formula gives good agreement with the Rydberg term scheme. The OVI wavelengths measured from the dispersion curve and shown in Table I are less accurate than the calculated wavelengths, the latter providing useful wavelength standards in this spectral region.

For OVII the triplet 1s 2s, and 1s 2p term values are also known and a Ritz formula was again used to identify the higher series member. The 1s 2p $^3P_2^o$ - 1s 3s $^3S_1$ identification of OVII is questionable however since no further members of this series were observed.

Transitions marked in Table I with an asterisk have been measured previously by Edlen (1934) and are listed by Kelly (1959).

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TABLE I

SPECTRA OF OVI AND OVII AS MEASURED FROM MAGGI I THETATRON

(Accuracy ± 0.05 Å)

OVII

λ Å	Intensity	Classification
* 128.44	7	$1s2p\,^3P^o_2 - 1s3d\,^3D_3$
96.12	6	$1s2p\,^3P^o_2 - 1s4d\,^3D_3$
86.07	4	$1s2p\,^3P^o_2 - 1s5d\,^3D_3$
81.50	2	$1s2p\,^3P^o_2 - 1s6d\,^3D_3$
78.94	1	$1s2p\,^3P^o_2 - 1s7d\,^3D_3$
* 120.37	7	$1s2s\,^3S_1 - 1s3p\,^3P^o$
91.02	5	$1s2s\,^3S_1 - 1s4p\,^3P^o$
81.89	3	$1s2s\,^3S_1 - 1s5p\,^3P^o$
133.31	5	$1s2p\,^3P^o_2 - 1s3s\,^3S_1$

OVI

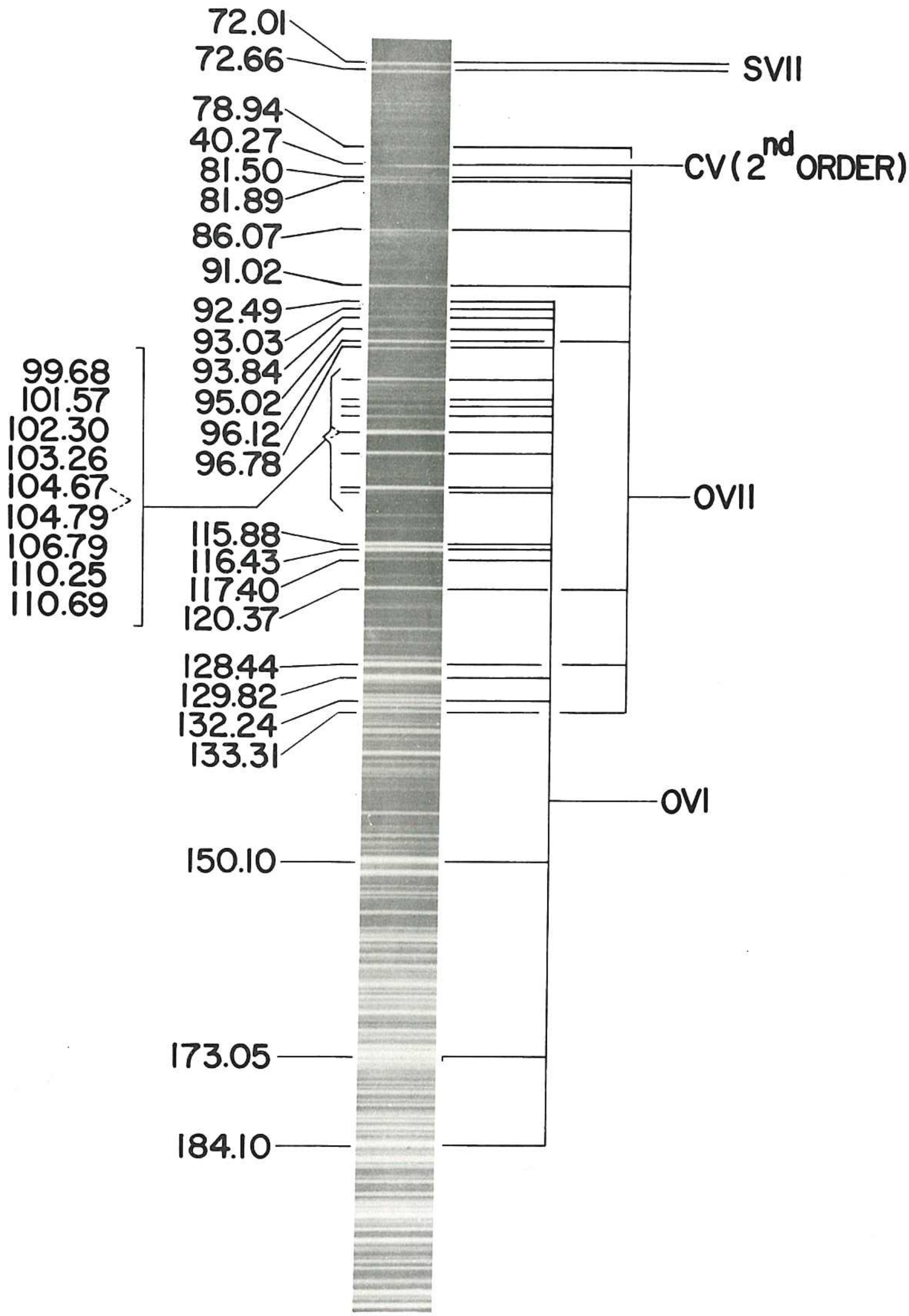
λ Å	Intensity	Classification
129.82	8	$2p\,^2P^o_{3/2} - 4d\,^2D_{2\frac{1}{2}}$
* 116.43	7	$2p\,^2P^o_{3/2} - 5d\,^2D_{2\frac{1}{2}}$
* 110.25	7	$2p\,^2P^o_{3/2} - 6d\,^2D_{2\frac{1}{2}}$
106.79	6	$2p\,^2P^o_{3/2} - 7d\,^2D_{2\frac{1}{2}}$

TABLE I
(continued)

OVI

λ Å	Intensity	Classification
104.67	5	$2p\,^2P^o_{3/2} - 8d\,^2D_{2\frac{1}{2}}$
103.26	4	$2p\,^2P^o_{3/2} - 9d\,^2D_{2\frac{1}{2}}$
102.30	3	$2p\,^2P^o_{3/2} - 10d\,^2D_{2\frac{1}{2}}$
101.57	2	$2p\,^2P^o_{3/2} - 11d\,^2D_{2\frac{1}{2}}$
* 132.24	6	$2p\,^2P^o_{3/2} - 4s\,^2S_{\frac{1}{2}}$
117.40	6	$2p\,^2P^o_{3/2} - 5s\,^2S_{\frac{1}{2}}$
110.69	3	$2p\,^2P^o_{3/2} - 6s\,^2S_{\frac{1}{2}}$
* 150.10	8	$2s\,^2S_{\frac{1}{2}} - 3p\,^2P^o_{3/2}$
* 115.88	7	$2s\,^2S_{\frac{1}{2}} - 4p\,^2P^o_{3/2}$
* 104.79	7	$2s\,^2S - 5p\,^2P^o$
99.68	5	$2s\,^2S - 6p\,^2P^o$
96.78	5	$2s\,^2S - 7p\,^2P^o$
95.02	4	$2s\,^2S - 8p\,^2P^o$
93.84	3	$2s\,^2S - 9p\,^2P^o$
93.03	2	$2s\,^2S - 10p\,^2P^o$

* Wavelengths listed in 'Vacuum Ultraviolet Emission Lines' by R.L. Kelly, UCRL 5612



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Emission spectrum from the Theta pinch in the wavelength range 200 Å to 70 Å