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The Ni I spectrum and term system. A progress report

ABSTRACT

The Ni I spectrum is being analyzed in the region 1600 - 50 000 Å. The first results comprise the classification of 375 lines in the infrared region and the establishment of numerous new levels of high configurations.

INTRODUCTION

The most recent analysis of the Ni I spectrum was published by Russell in 1929, and no new levels have been reported since that work 60 years ago. Although Russell's analysis was very comprehensive, it is possible to extend and improve it today by extending the observed wavelength region in the infrared, by improving the wavelength accuracy, and by using theoretical methods for predictions and interpretation. Besides the interest inherent in the analysis of the complex structure of a system involving equivalent d electrons, increased knowledge of the Ni I spectrum is important for astrophysical work due to the high cosmic abundance of nickel.

NEW OBSERVATIONS

In the present investigation the nickel spectrum emitted from a hollow cathode has been recorded in the region 1600 - 4000 Å on the 10.7-m normal incidence spectrograph at the National Institute for Standards and Technology (NIST), Gaithersburg, and in the region 2900 - 55 000 Å on the Fourier transform spectrometer at the National Solar Observatory at Kitt Peak.

In the infrared region partly resolved isotope structure is observed for numerous lines connecting the two configuration types $3d^9nl$ and $3d^84snl$.

THE ENERGY LEVEL SYSTEM

From Russell's work the $3d^9nl$ system was well known as regards the configurations $3d^94s$, 5s, 6s, 4p, 5p, 3d, 4d and (partly) 5d. In the $3d^84snl$ system only $3d^84s^2$ was completely known. A number of levels from higher parents were missing in 4s4p, and only levels from the lower parents were reported in 4s5s and 4s4d.

In the present work the analysis was started in the infrared region, where only 17 lines were previously known (Fisher et al., 1959). The analysis has this far yielded levels of the configurations $3d^97s$, 6p, 4d, 4f, 5f, and 5g; and $3d^84s5p$. Furthermore, the accuracy of the relative energy values of the high levels has been considerably improved due to the identification of numerous ir lines connecting these levels. 375 observed lines in the region 11 150 - 55 000 Å have been identified this far.

The continued work will mainly lead to an extended knowledge of the $3d^84snl$ system, thus increasing the number of classified Ni I lines over the whole observed region.

Ni I IN THE INFRARED SOLAR SPECTRUM

By comparing nickel hollow cathode spectra with the infrared solar spectrum, Biémont et al. (1986) were able to identify some 200 solar lines in the region 11 130 - 41 500 Å as due to Ni I or Ni II. 130 of these lines have now been classified as transitions between high Ni I levels, i.e. transitions of the types 5s - 5p, 5p - 6s, 5p - 5d, 4d - 4f, 4d - 5f, and 4f - 5g. Increased knowledge of the configurations $3d^84snl$ will greatly increase the possibilities for further identifications in this region.

As an example of the solar identifications all the Ni I 4d - 4f, 4d - 5f, and 4f - 5g lines present in the solar spectrum are reported in Table 1.

REFERENCES

Biémont, E., Brault, J.W., Delbouille, L., and Roland, G., 1986 - The nickel spectrum in the infrared. Application to the solar spectrum. In: Astron. Astrophys. Suppl. Ser. 65, 21.

Fisher, R.A., Knopf Jr., W.C., and Kinney, F.E., 1959 - Laboratory wave lengths and intensities in the near infrared spectra of nine elements. In: Astrophys. J. 130, 683.

Russell, H.N., 1929 - The arc spectrum of nickel. In: Phys. Rev. 34, 821.

Table 1. Ni I lines in the infrared solar spectrum classified as 4d-4f, 4d-5f and 4f-5g. The laboratory data are preliminary.

Laboratory		Sun	
Intensity	σ(cm^{-1})	σ(cm^{-1})	Combination
84	2506.057	.054	$4f(5/2)[11/2]_6$ - $5g(5/2)[13/2]_7$
79	2506.494	.491	$4f(5/2)[11/2]_5$ - $5g(5/2)[13/2]_6$
154	5400.934	.956	4d f^3D_2 - $4f(5/2)[5/2]_2$
380	5418.860	.845B	4d e^1F_3 - $4f(3/2)[7/2]_4$
306	5484.603	.604	4d f^1D_2 - $4f(3/2)[5/2]_3$
678	5519.013	8.986?	4d e^1G_4 - $4f(3/2)[9/2]_5$
76	5540.043	.028	4d e^3P_2 - $4f(5/2)[1/2]_1$
46	5540.735	.789B	4d e^3P_1 - $4f(5/2)[3/2]_1$
1123	5541.465	.453B	4d e^3G_4 - $4f(5/2)[11/2]_5$
155	5541.906	.907B	4d e^3P_1 - $4f(5/2)[3/2]_2$
550	5549.511	.568B	4d e^3G_3 - $4f(3/2)[9/2]_4$
206	5557.590	.588	4d e^3P_1 - $4f(5/2)[5/2]_2$
39	5557.752	.744	4d e^3G_5 - $4f(5/2)[11/2]_5$
1404	5558.192	.186	4d e^3G_5 - $4f(5/2)[11/2]_6$
101	5567.385	B	4d e^3G_4 - $4f(5/2)[9/2]_4$
300	5568.940	.930	4d e^3P_2 - $4f(5/2)[5/2]_3$
68	5571.994	.993B	4d e^3G_3 - $4f(3/2)[7/2]_3$
58	5678.769	.782B	4d e^1P_1 - $4f(3/2)[3/2]_1$
116	5745.052	.040	4d e^3S_1 - $4f(5/2)[1/2]_0$
218	5745.759	.752	4d e^3S_1 - $4f(5/2)[1/2]_1$
195	5758.570	.562	4d e^3S_1 - $4f(5/2)[3/2]_1$
60	8030.306	.303	4d e^3G_4 - $5f(5/2)[11/2]_5$
17	8039.959	.967	4d e^3P_1 - $5f(5/2)[5/2]_2$
78	8046.949	.945	4d e^3G_5 - $5f(5/2)[11/2]_6$
19	8054.047	.023?	4d e^3P_2 - $5f(5/2)[5/2]_3$

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