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Tc and Other Unstable Elements in Przybylski's Star

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Abstract. A study of recent high-resolution spectra of the very unusual magnetic Ap star HD 101065 = V816 Cen has revealed the presence of many lines of the unstable elements Tc, Pm, Po, Ac, Pa, and the transuranics Np through Es. The isotopes involved are not known. Because of the short lifetimes of some of these elements, it seems likely that surface nuclear reactions are responsible for their presence. Solar-flare-like activity is suggested.

Przybylski's star has long been known to be a very peculiar object (Kurtz 2002). A recent study of the visual region of the spectrum (Cowley et al. 2000) has confirmed that the atmosphere is surprisingly deficient in iron, but is greatly overabundant in the rare-earths as well as vanadium and cobalt. Recent additional spectra were obtained by G. Mathys at ESO that cover the ultraviolet down to 3047 Å. Dr. Cowley has measured about 13,000 lines in the spectrum and asked me to attempt a complete line identification, which I have done, using the customary qualitative approach.

After dealing with the usual elements, I turned to the unstable ones, and was much surprised to find that there was good evidence for these. A summary of my work is given in the accompanying tables: one listing all of the elements detected in the star, and the other giving information on the unstable elements. The wavelength tolerance was generally .07 Å. The lines are slightly broadened and there is much blending.

One of the concerns in this work is the accuracy of the laboratory data, especially for the less-well-known elements. Isotope shifts, which are unknown, can be expected to run to .05 Å or more. There are certainly difficulties in this sort of work, but I did the best I could. Undoubtedly, many of the supposed identifications will be found to be unimportant. Previous results are well confirmed. The vanadium and cobalt excesses are very obvious, as well as the iron deficiency. It really seems that extensive element transformation has occurred — iron to cobalt for example — and many others. This sounds like a nuclear physics problem to me.

I believe that solar-flare-like activity is to blame. After all, the star is magnetic and there would be no shortage of very-high-energy particles. I leave the details to the experts.

Three additional points:

1. I have recently (Bidelman 2002) suggested that the Ap stars may be examples of binary-star merger. If so, Przybylski's star may be a recent addition to the group.

2. I discovered long ago (Bidelman 1960) that the B-type star 3 Cen possesses very strong lines of phosphorus. When this star was studied at Mount Wilson it was found to have lines of ^{3}He rather than the expected ^{4}He (Sargent and Jugaku 1961). This was quite a surprise. What we didn't know then was that impulsive solar flares produce this sort of helium. Surprisingly, no one seems to have drawn the connection.

3. Finally, Przybylski's star is not unique (Hubrig et al. 2002). HD 217522 has similar peculiarities, but sharper spectral lines.

Table 1. Element Occurrence in Przybylski's Star

Element	I	II	III	Notes
H	X			
He				
Li	2			Li 7
Be		2		
B		1		
C	X			
N,O,F,Ne				
Na	X			
Mg	X	X		
Al	X			
Si	X	X		
P,S,Cl,Ar,K				
Ca	X	X		
Sc	?	X		
Ti	X	XX	X	
V	XX	XX	X	
Cr	X	X		
Mn	X	XX		
Fe	X	X		
Co	X	XX		
Ni	X			
Cu	X	X		
Zn	X			
Ga,Ge				
As	X			
Se	?			
Br	X			
Kr	X			
Rb				
Sr	X	2	X	
Y	X	XX	X	
Zr	X	XX	1	

Table 1 (Continued)

Element	I	II	III	Notes
Nb	X	X	1	
Mo	XX	XX		
Tc	XX	X		
Ru		?		
Rh	X			
Pd	XX			
Ag	2			
Cd	1	X	1	
In	1			
Sn	1	?		
Sb, Te, I	?			
Xe	X	X		
Cs				
Ba	X	X		
La, Ce	XX	XX	X	
Pr	X	XX	XX	
Nd	X	XX	X	
Pm	XX	XX		
Sm	X	XX	no data	
Eu	X	XX	X	
Gd	XX	XX	XX	
Tb	XX	X	no data	
Dy	XX	XX	X	
Ho	XX	XX	no data	
Er, Tm	XX	XX	X	
Yb	X	X	2	
Lu		X	1	
Hf	X	X	X	
Ta	X	XX	no data	
W	XX	?		
Re	X	1	no data	
Os, Ir	X		no data	
Pt	XX		no data	
Au	XX			
Hg	X	X		
Tl	X	XX		
Pb	X			
Bi	1			
Po	X			
At	no data			
Rn	?			
Fr	no data			
Ra	?			

Table 1 (Continued)

Element	I	II	III	Notes
Ac, Th	X	X	X	
Pa	X	X		
U		X		few lines
Np	X	1		
Pu, Am, Cm	X	X		
Bk, Cf, Es	X	X		

Table 2. Unstable Elements Summary

No.	Element	all lines	lines found	% in line list
43	Tc I	408	207	51
	II	16	10	62
61	Pm I	224	121	54 + many more added
	II	182	95	52 + many more added
84	Po I	45	35	78
	II		no data	
89	Ac I	16	7	44
	II	45	26	58
91	Pa I	26	14	54
	II	27	13	48
93	Np I	25	7	28
	II	1	1	100
94	Pu I	107	59	55
	II	72	48	67
95	Am I	25	17	68
	II	33	22	67
96	Cm I	84	43	51
	II	15	9	60
97	Bk I	100	54	54
	II	36	18	50
98	Cf I	30	16	53
	II	8	8	100
99	Es I	63	35	56
	II	8	4	50

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