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ABSORPTION SPECTRUM OF Pm\*3 IN D2O, DC1

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ABSORPTION SPECTRUM OF  $\text{Pm}^{+3}$  IN  $\text{D}_2\text{O}$ ,  $\text{DCl}$

John B. Gruber and John G. Conway

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## ABSTRACT

Under higher resolution than previously reported, the absorption spectrum of  $\text{Pm}^{+3}$  in  $\text{D}_2\text{O}, \text{DCl}$  was studied from 2700 to 19,000 Å. Although additional structure is observed in the ultraviolet region, nothing is seen from 8233 to 19,000 Å.

ABSORPTION SPECTRUM OF  $\text{Pm}^{+3}$  IN  $\text{D}_2\text{O}, \text{DCl}$ 

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Three groups of investigators have already reported the general structure of the solution absorption spectrum in  $\text{Pm}^{+3}$  between 3000 and 10,000 Å.<sup>1,2,3</sup> In every case reported, the instrument employed was either a Model-LD or Model-DU Beckman spectrophotometer, and the largest amount of material handled was 5 mg.

We wish to report the absorption spectrum of  $\text{Pm}^{+3}$  in 0.023 M DCl (98%  $\text{D}_2\text{O}$ ) from 2600 Å to 19,000 Å under higher resolution than previously reported. Using a Cary Model-14 recording spectrophotometer, we have observed additional structure in the ultraviolet region. Molar extinction coefficients were calculated for all peaks from 2600 to 8233 Å. No additional peaks were observed from 8233 to 19,000 Å.

An emission-spectrum analysis of  $\text{Pm}^{+3}$  in 1 M HCl solution obtained from Oak Ridge National Laboratory indicated impurities of Nd, Sm, Al, Ca, and Am. Purification of 60 mg of  $\text{Pm}^{+3}$  was carried out by the use of a heated (87°C) Dowex-50 cation-exchange column with  $\alpha$ -hydroxybutyric acid as eluting solution.<sup>4</sup> After all other rare-earth impurities were separated from  $\text{Pm}^{+3}$ , the column was converted to a 12 N HCl column and  $\text{Pm}^{+3}$  was separated from actinide impurities.<sup>4</sup>

The  $\text{PmCl}_3$  solution was then taken to complete dryness under a heat lamp, and 30 ml of DCl,  $\text{D}_2\text{O}$  solution added. The drying procedure was again repeated, and again new  $\text{D}_2\text{O}, \text{DCl}$  solution added, giving a final solution of  $\text{PmCl}_3$  in  $\text{D}_2\text{O}, \text{DCl}$ .

The solution used in the absorption cells was analyzed before and after each run. The concentration of  $\text{Pm}^{+3}$  was determined by  $4\pi$  beta counting, and the chloride concentration by the Volhard method. The amount of  $\text{H}_2\text{O}$  in the  $\text{Pm}^{+3}$  sample was obtained by comparison with known solutions of  $\text{H}_2\text{O}$  in the  $\text{D}_2\text{O}$  stock. One sample contained 30.0 mg  $\text{Pm}^{+3}$  per 5.23 ml 0.023 M DCl (98%  $\text{D}_2\text{O}$ ).

The Cary 14 spectrophotometer was calibrated at the factory with an AH4 Hg arc. The  $\text{Nd}^{+3}$  and  $\text{Am}^{+3}$  standards were run in this laboratory in order to check the absolute values of peak wave lengths. The calibration results indicated the instrument to be correct to 1.5 Å in the region from 2700 to 4900 Å and 2 Å from 4900 Å to 2  $\mu$ . The resolving power of the monochromator is about 1.0 Å in the ultraviolet and visible ranges and about 3.0 Å in the near infrared. The wave length scale is reproducible to 0.5 Å. Table 1 includes corrected wave length values. The uncertainty in peak locations is  $\leq 2$  Å. Slit widths and molar excitation coefficients,  $\epsilon$ , are also given.

The  $\text{Pm}^{+3}$  solution spectrum was compared with solution spectra of  $\text{Eu}^{+3}$ ,  $\text{Nd}^{+3}$ ,  $\text{Sm}^{+3}$ , and  $\text{Am}^{+3}$ . No trace of the rare-earth ions was observed. A trace of  $\text{Am}^{+3}$  was detected by  $\alpha$ -assay (0.06 mg/ml). Consequently, the  $\text{Am}^{+3}$  peaks at 5033 and 8152 Å were subtracted from the promethium spectrum and the remaining peaks taken as  $\text{Pm}^{+3}$  peaks. The solution absorption spectrum is shown in Fig. 1.

Since additional peaks are not observed from 0.8  $\mu$  to 1.9  $\mu$ , the groundstate multiplets,  $^5\text{I}_4$  to  $^5\text{I}_8$ , should be separated by less than 5400  $\text{cm}^{-1}$ . The group of peaks around 8000 Å are probably due to transitions from  $^5\text{I}_4$  to the  $^5\text{F}$  and  $^5\text{S}$  multiplets. However, an analysis of the  $\text{Pm}^{+3}$  spectrum is best undertaken by studying the ion in a solid matrix. Such studies have already begun.

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Table I

Absorption peaks of  $\text{Pm}^{+3}$  in 0.023 M DCl (98%  $\text{D}_2\text{O}$ )

$\lambda$ , Wave length of peak ( $\text{\AA}$ )	Band width at half max. ( $\text{\AA}$ )	Slit width (mm)	$\epsilon$ , molar excitation coefficient <sup>a</sup>
2610	-2690	0.080	----
3074	3056-3081	0.075	0.32
3126'	3113-3139	0.061	0.77
3153	3147-3160	0.061	0.31
3200	3187-3213	0.061	2.53
3281	3268-3294	0.061	4.96
3329	3316-3342	0.061	4.73
3440	3413-3460	0.061	0.39
3870	3845-3890	0.030	0.21
4015	4000-4057	0.021	0.51
4226	4200-4250	0.017	0.20
4496	4472-4520	0.016	0.41
4583	4566-4600	0.015	0.69
4933	4890-4986	0.013	1.41
5448	5431-5470	0.012	3.40
5476	5470-5502	0.012	3.33
5679	5638-5700	0.013	3.77
5750	5726-5760	0.013	0.64
5905	5879-5929	0.013	0.23
6261	6226-6300	0.019	0.45
6838	6786-6886	0.048	2.13
6980	6962-7000	0.069	2.14
7019	7000-7036	0.071	2.54
7152	7128-7176	0.075	0.36
7347	7272-7400	0.13	3.05
7824	7725-7872	0.40	1.54
8010	7974-8046	0.52	0.85
8057	8046-8080	0.52	0.74
8233	8200-8245	0.71	0.24

(No other absorption peaks were seen to 1.89  $\mu$ )

<sup>a</sup>  $\log \frac{I_0}{I} = A = \epsilon bc$ , where A is the absorbance,  $\epsilon$  is in liters  $\times$   $\text{cm}^{-1}$   $\times$  moles<sup>-1</sup>,  
b is the cell path length -- 2.001 cm, and c is in  
moles per liter.

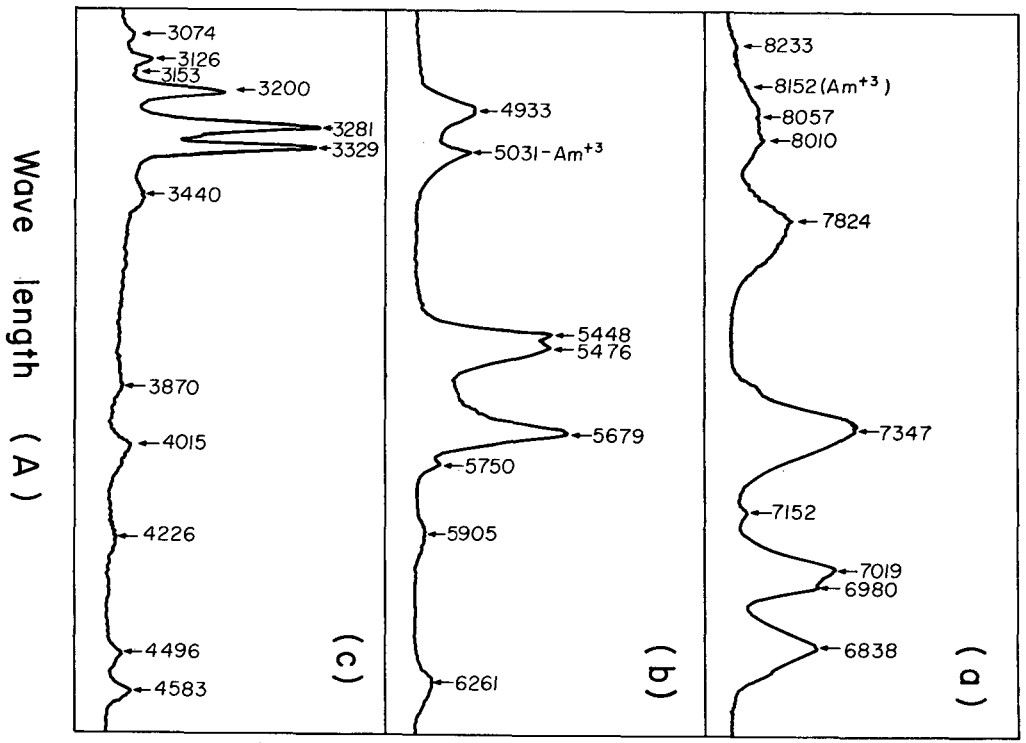


FIGURE LEGEND

Figure 1. Solution absorption spectrum of 0.039 M  $\text{Fm}^{+3}$  in  
0.023 M DCl (98%  $\text{D}_2\text{O}$ ).

- (a) 6700 to 8300 Å; (b) 6300 to 4700 Å; and  
(c) 4700 to 3000 Å.

Relative intensity



MU-19420