MAGNETIC PROPERTIES OF LUTECIUM

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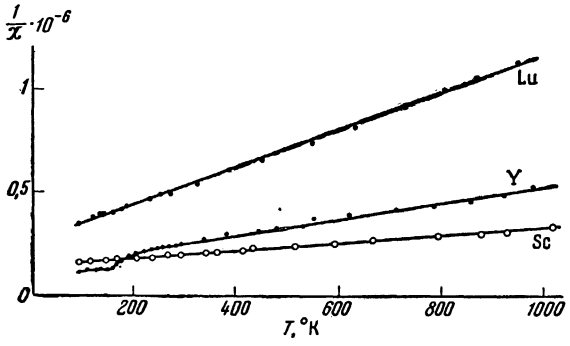
The temperature dependence of the magnetic susceptibility of metallic lutecium was investigated between 77 and 1000° K. It was found that $d\chi/dT$ and Θ_p are negative.

AN investigation of the temperature dependence of the magnetic susceptibility of the weakly magnetic transition metals scandium and yttrium[1,2] showed that the derivative of their susceptibility with respect to temperature, $d\chi/dT$, and the paramagnetic Curie point Θ_p are both negative. As is known, these metals have one uncompensated spin in the 3d- and 4d-shells, respectively. It was of interest to investigate the temperature dependence of the magnetic susceptibility of lutecium which also has one electron (in the 5d-shell). Metallic lutecium crystallizes in a hexagonal close-packed lattice with a distance a = 3.509 A between neighboring atoms. The electronic configuration of the lutecium atom (without the ytterbium atomic shells) is $5d6s^2$.

According to the chemical analysis, the metallic lutetium contained the following impurities: ≤ 0.002% calcium, ≤ 0.005% copper, ≤ 0.0055% iron, ≤ 0.1% thulium. It contained, moreover, a certain amount of tantalum since the lutecium was prepared in tantalum crucibles. The temperature dependence of the magnetic susceptibility, determined for the first time in the present work, was investigated with a Sucksmith balance in the temperature range from 77 to 1000° K. Above room temperature, the measurements were carried out in vacuum.

The temperature dependence of the reciprocal of the specific susceptibility $1/\chi$ of lutecium, deduced from our measurements, is given in the figure, together with the corresponding dependences for scandium and yttrium, which have been included for comparison. It is evident that, over the whole investigated temperature range, $1/\chi$ varies linearly with temperature and that $d\chi/dT < 0$ for all three metals. We applied the Curie-Weiss law to the linear dependence of $1/\chi$ on T and determined the constants in that law.

We give below the values of the effective magnetic moment P_p, the Curie-Weiss constant C,



the paramagnetic Curie point, and the value of the atomic magnetic susceptibility at room temperature:

	$\chi_A \cdot 10^6$, 20°	C_A	P_p (μ_B)	Θ_p, °K
Sc {99,68:	280	0.35	1.67	—1050
Sc {99,88:	236	0.25	1.42	—700
Y:	370	0.22	1.34	—280
Lu:	336	0.19	1.22	—290

It is evident from the table that the atomic magnetic susceptibility of scandium, yttrium and lutecium is of the same order as that of other transition metals. Moreover, the sign of the derivative of the susceptibility with respect to temperature is the same (negative) for Sc, Y and Lu. It should also be noted that the electronic specific heat $C_e = \gamma T$ of scandium and yttrium, according to the work of Montgomery and Pells,[3] is of the same order of magnitude as that of other transition metals. Thus, for scandium and yttrium the coefficient γ is, respectively, 11.1 and 10 J-mole^{-1} deg compared with 15, 9.1, 13.0, and 8.7×10^{-3} J-mole^{-1} deg for Mn, V, Pd and Nb, respectively.[4-6]

Thus, the appearance of one electron in the d-band exerts a considerable influence on the physical properties on the metals Sc, Y and Lu. Here, obviously, we mean both collective-state electrons of the (d—S)-band and d-band electrons, which suffer some spatial localization and determine to a great extent the temperature dependence

of the susceptibility. Our data on the temperature dependence of the susceptibility of Sc, Y and Lu and the data of Montgomery and Pells on the electronic specific heat, indicate that the density of electron states in these metals is indeed high and that the Fermi energy should be close to the maximum of the density-of-states curve.

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[1] Chechernikov, Iuliu Pop, Naumkin, and Terekhova, JETP **44**, 387 (1963), Soviet Phys. JETP **17**, 265 (1963).

[2] Chechernikov, Iuliu Pop, Terekhova, and Kolesnichenko, JETP **46**, 444 (1964), Soviet Phys. JETP (in press).

[3] H. Montgomery and G. P. Pells, Proc. Phys. Soc. (London) **78**, No. 4, 622 (1961).

[4] Worley, Zemansky, and Boorse, Phys. Rev. **87**, 1142 (1952).

[5] Brown, Zemansky, and Boorse, Phys. Rev. **86**, 134 (1952).

[6] D. H. Parkinson, Reports on Progress in Physics (London) **21**, 226 (1958).

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