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We have studied the effect of very high pressures on the Mossbauer spectrum of Fe-57 in iron metal at seven pressures from one atmosphere to a pressure that is probably higher than 140 kbar. Up to a presumative pressure of about 120 kbar, the spectrum consists of six lines characteristic of Fe-57 in a ferromagnetic medium. In some of the spectra the two weak inner lines were poorly resolved. The magnitude of the magnetic splitting decreased slowly with pressure, consistent with a linear extrapolation of the nuclear magnetic resonance results of Benedek and Litster[1]. There was also a gradual chemical shift of the spectrum toward lower energies in agreement with the results of Pound et al.[2] Both of these effects could be attributed to an increased 4s electron density at the nucleus.

At 140 kbar (Fig. 1), a seventh line appeared in the spectrum near zero velocity (at -.134 ±.067 mm/sec). This line probably was due to the appearance of the high pressure hexagonal close packed phase which has been reported by a number of workers.[3-5] Jamieson and Lawson[5] report that the transition is not sharp, that both cubic and hexagonal phases coexist over a broad transition region. This could explain the coexistence of a six line (bcc) and an apparent single line (hcp) spectra. The present data seem to indicate that in the hexagonal phase the Fe-57 was not aligned.

The source of the recoilless radiation was a disc of Fe-56 metal .175 inch in diameter and .007 inch thick onto the edge of which 4 millicuries of Co-57 had been electroplated along one-half of the circumference. The sample was annealed for two hours at 1000°C in a hydrogen atmosphere to permit the Co-57 to diffuse into the iron lattice. The sample was contained in a pair of modified Bridgman anvils[6] by a pyrophyllite ring, .250 inch in diameter, .010 inch high and .030 inch thick. The ring was coated with $Fe^{56}_2O_3$ to increase the friction between the ring and the anvils while minimizing the self-absorption of the recoilless radiation. The 14-kev radiation was attenuated seriously by the ring, and this placed an upper limit on the pressures which could be used. Pressures quoted here were the average pressures on the .250 inch diameter anvil face. The actual pressure at the edge of the disc from which the radiation eminated was not known, but may be appreciably higher.

The radiation passing through the ring was passed through an absorbing foil of a 19% Cr - 9% Ni stainless steel which was enriched to nearly 70% Fe-57. This foil was rolled to .0007 inch thickness and had a broad single absorption line. The foil was attached to an "automatic" loudspeaker spectrometer similar to that described by Shirley et al.[7] which was modified to permit a sodium iodide detector of the transmitted gamma rays to be inserted between the foil and the drive mechanism. A sinusoidal drive was used, and the intensity of the 14-kev radiation transmitted at each of nearly 390 velocities was collected on a 400 channel pulse height analyzer. This spectrum was normalized for the variation in time spent at each velocity.

From the estimates of Walker, Wertheim and Jaccarino,[8] the magnitude of the chemical shift observed to 140 kbar corresponds to an increase in the 4s electron density at the nucleus of the order of 10%. This corresponds with the percentage decrease in the volume of iron reported at 8% to 131 kbar.[4] Whether the magnitude of the decrease in the magnetic splitting could be explained in the same manner is not completely understood; however, the decrease in the splitting is in the direction expected from an increasing 4s electron density at the nucleus if the spin orientation was unaffected by the compression.

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NOTE: Refer to UCRL-10785 for more recent information.

Figure Caption

Fig. 1. 140 kbar iron spectrum. The solid lines indicate the position and intensities of the seven lines (calculated for the two inner lines of the α-iron spectrum).

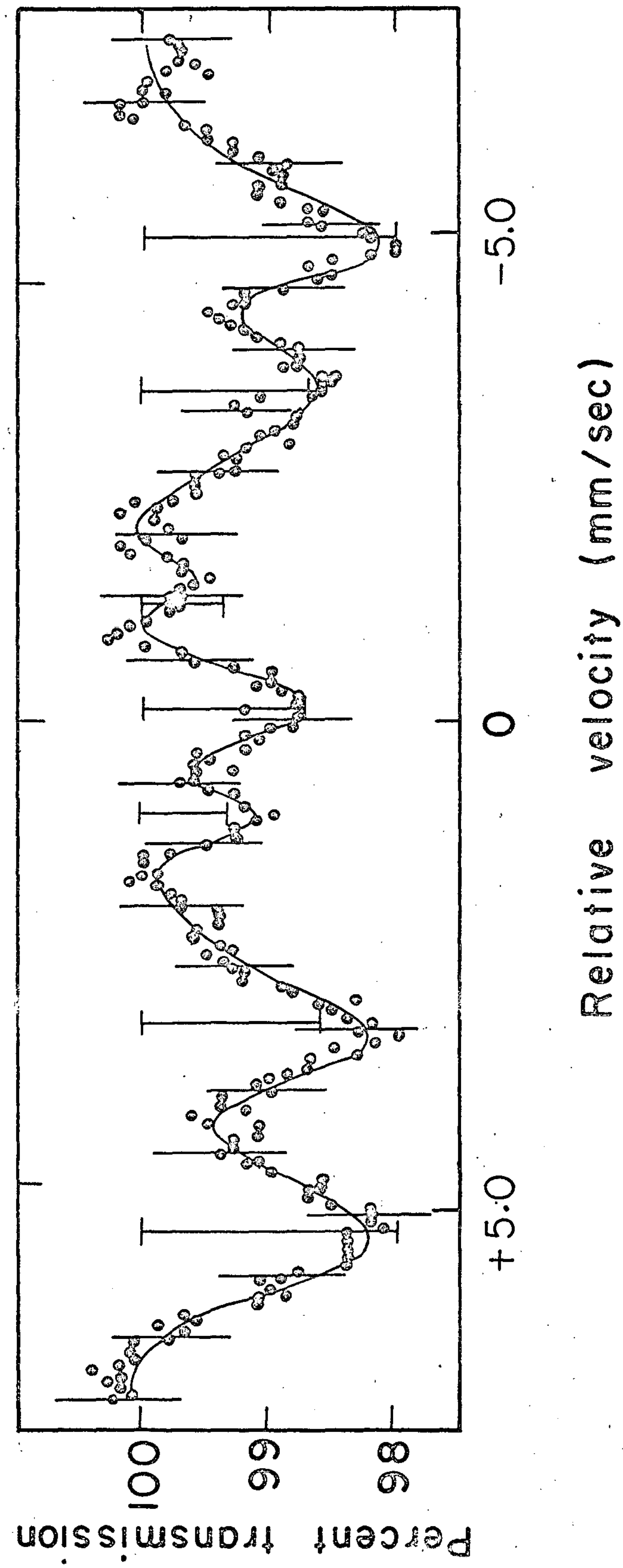

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Fig. 1.