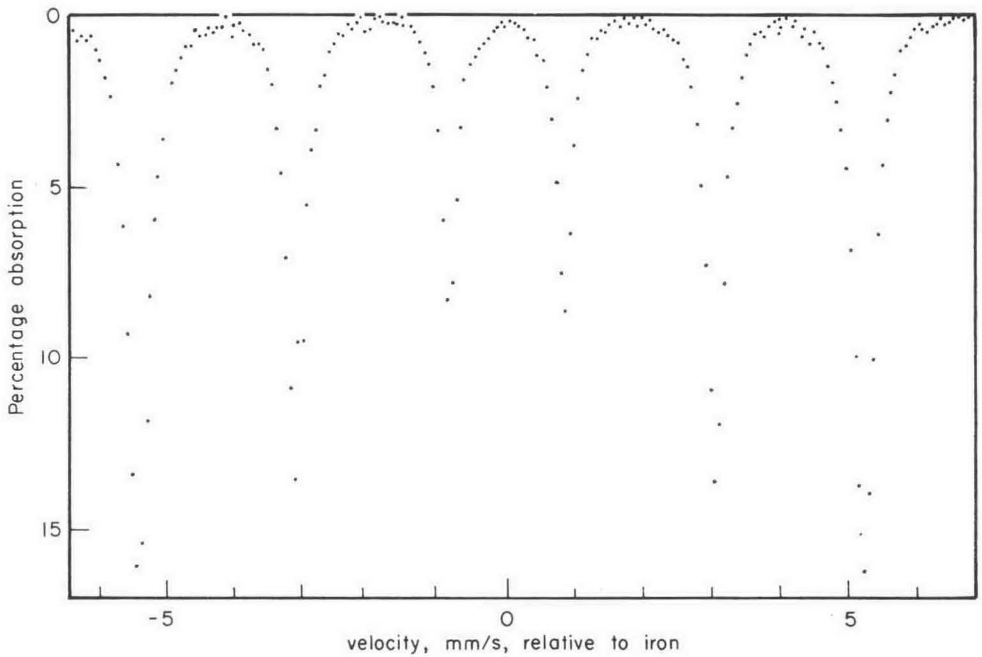

Figure 3. ^{57}Fe Mössbauer spectrum of 0.001″ shim steel at room temperature. The splitting of these lines arises from the internal magnetic field of 330 kilogauss.

iron carbide, and vanish for austenite. The technology of steels comprises an expanding field for the Mössbauer technique. A compound need not be ferromagnetic for the existence of large internal magnetic fields. Paramagnetic compounds below the Neél temperature become magnetically ordered. The local field at the nucleus may be quite large, although the net external field is essentially zero. Hematite (Fe_2O_3) is antiferromagnetic at room temperature. The internal magnetic field is 510 kG.[6] Magnetite (Fe_3O_4) has a spine structure, with ferrous and ferric iron atoms in octahedral and tetrahedral sites. The internal magnetic fields differ for these different kinds of iron, and the Mössbauer technique is being used for the study of such materials (Fig. 4).

Another readily measured parameter is the position of the center of the spectrum, relative to some fixed energy. This has been termed " isomer shift ", and arises in part from chemical differences of bonding. Specifically, the isomer shift measures the " s " electron density at the iron nucleus. This varies with valence state, as well as ligand configuration and strength. The isomer shift also depends on temperature in a very interesting way.[7,8] The energy of the gamma ray measured in the rest frame of the nucleus is a constant. A consequence of special relativity is that a moving clock appears to keep time more slowly than does a stationary clock. Atoms move faster as the temperature is raised. The Mössbauer radiation from a hot source is accordingly lower in energy when measured in the laboratory frame of reference, and it must have an additional Doppler velocity added to achieve a given resonance.

Most spectra of diamagnetic iron compounds consist of two lines. The splitting arises from the interaction between the quadrupole moment of the excited nuclear state and the asymmetric distribution of charge about the nucleus.[6] The ground state has no nuclear quadrupole moment. The electric field gradient tensor measures the deviation of the charge cloud about the nucleus from spherical symmetry. This distortion may be prolate (football shaped) or oblate (pancake-shaped), or may even lack axial symmetry. Two sources of the electric field gradient tensor may be present in a given structure. The ligand asymmetry, weighted according to ligand strength, is one factor. Non-spherical distributions of electrons, such as uncompensated $3d$ electrons, also contribute. Experience