(NZF) NMR. We show that application of weak magnetic fields results in splitting of the zero-field (ZF) lines, restoring information about gyromagnetic ratios that is lost in ZF NMR. In the regime where the Zeeman effect can be treated as a perturbation, we observe high-resolution spectra with easy-to-understand splitting patterns that are in good qualitative and quantitative agreement with first-order perturbation theory. This work represents the first observation of NMR under such conditions, forming the basis for a new type of NMR spectroscopy that serves as a complement to high-field NMR, where heteronuclear couplings are almost always treated as a small perturbation to the much larger Zeeman interaction. We also examine the case in which the Zeeman energies are comparable to the J-coupling energies, resulting in spectra of maximal complexity.

The Hamiltonian in the presence of J-couplings and a magnetic field is

$$H = \hbar \sum_{j;k>j} J_{jk} \mathbf{I}_j \cdot \mathbf{I}_k - \hbar \sum_j \gamma_j \mathbf{I}_j \cdot \mathbf{B}. \qquad (1)$$

Here $\mathbf{I}_j$ represent both like and unlike spins with gyromagnetic ratio γ_j and J_{jk} is the scalar coupling between spins j and k. In the absence of magnetic fields, the spherical symmetry of the Hamiltonian dictates that eigenstates $|\phi_a\rangle$ are also eigenstates of $\mathbf{f}^2$ and f_z, where $\mathbf{f}$ is the total angular momentum $\mathbf{f} = \sum_j \mathbf{I}_j$, with energy E_a, and degeneracy $2f + 1$. Application of a magnetic field B_z lifts this degeneracy, splitting the ZF NMR lines.

We first examine the effects of very small magnetic fields on a $^{13}CH_N$ system, with N equivalent protons, using perturbation theory. In zero field, the unperturbed energy levels are given by $E(f, k) = J/2[f(f+1) - k(k+1) - s(s+1)]$, [14] where $k = 1/2, 1, 3/2 \ldots$ are the possi-