different scatterers, viz., Be, C (graphite, polystyrene, apiezon oil), Mg, Al, Cu, and Fe at calculated positions, most of them are, however, extremely weak in intensity and it has not been possible to take their microphotometer records. It is hoped that by using the high light gathering power spectrograph, high contrast films, strong x-ray sources, and selecting suitable angles of scattering so as to have the minimum background due to the tail of the Compton band or the higher order Bragg reflections due to the white part of the target radiation, it will be possible to study, from this newly observed modified scattering, the term values of the elements and also the energy levels of the solid state.

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GROUND STATE Λ-DOUBLING TRANSITIONS OF OH RADICAL*

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One of the molecules whose presence in interstellar space may be detectable by means of its radio-frequency spectrum is the OH radical.[1] Attempts at observing it with radio telescopes have been unsuccessful thus far.[2] To make future searches more fruitful, frequencies of the appropriate absorption lines were measured in the laboratory with a Zeeman-modulated spectrometer.

For OH, at temperatures prevailing in interstellar space, only the lowest rotational state ($J=\frac{3}{2}$) of the $^2\Pi_{3/2}$ electronic state will be appreciably populated. This lowest energy level is split by Λ doubling into two levels 1666.4 Mc/sec apart. Each of the two Λ-doublet levels is split further by hyperfine interactions with the hydrogen nucleus, so that the spectrum consists of four absorption lines. The two stronger transitions, having no change in the total angular momentum $F(\Delta F=0)$, were measured and their frequencies are given in Table I together with frequencies calculated from expressions given by Dousmanis, Sanders, and Townes.[3] According to theory, the intensity ratio between the $F=2\leftarrow F=2$ and $F=1\leftarrow F=1$ transitions should be 9:5, and this was verified experimentally. Substantially the same ratio should prevail in interstellar space. The transitions with $\Delta F=\pm 1$ are expected to be about ten times weaker and have not been observed as yet.

Table I. Observed and calculated frequencies for Λ-doubling transitions in $J=\frac{3}{2}$ rotational state of $^2\Pi_{3/2}$ electronic state of OH radical.

Hyperfine transition	Experimental frequency (Mc/sec)	Calculated frequency (Mc/sec)
$F=2\leftarrow F=2$	1667.34 ± 0.03	1666.5
$F=1\leftarrow F=1$	1665.46 ± 0.10	1664.6

OH radicals were produced outside the absorption cell by an electrodeless radio-frequency discharge.[3] The microwave spectrometer was conventional in design except for the Zeeman-modulation technique. The absorption cell was a glass-lined, coaxial waveguide about $2\frac{1}{2}$ feet long and $1\frac{1}{4}$ inches in diameter. This coaxial cell was used both to propagate low-frequency microwave power and to provide Zeeman modulation. The modulating magnetic field was obtained by passing a large current through the center rod and back along the outer conductor. This produces a magnetic field between the two conductors which ideally does not extend outside the waveguide. The very small leakage fields which were obtained produced only very low pickup in the detecting circuits, whereas the pickup was quite troublesome when a conventional solenoid was wound around the waveguide and used for Zeeman modulation. The modulating current consists of a 100-kc/sec sine wave current superimposed on a direct current, in such ratio that the minimum of the sin wave corresponds to zero current. With a modulator whose maximum output was 25 peak-to-peak amperes, adequate modulation fields were obtained for both $^2\Pi_{1/2}$ and $^2\Pi_{3/2}$ states of OH. This technique for Zeeman modulation can also be applied to a standard Stark cell with the Stark septum acting as the center conductor.

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EVIDENCE FOR SHELL-MODEL STATES IN Sc^{41}†

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The excited states of the mirror nuclei Ca^{41} and Sc^{41} are of considerable interest because of the possibilities they present for testing the predictions of the shell model under quite favorable circumstances. According to this model, the ground states of these nuclei are described by single particles in the $f_{7/2}$ shell outside a Ca^{40} core described by closed $(1s)^4(1p)^{12}(1d, 2s)^{24}$ shells. Single-particle excited states are predicted approximately in the order $p_{3/2}$, $p_{1/2}$, $f_{5/2}$, $g_{9/2}$, $d_{5/2}$, and $g_{7/2}$. In addition, states of more complex character are expected due to the excitation of nucleons from the Ca^{40} core.[1] These states should be bound in the case of Ca^{41} for which the separation energy of a neutron is 8.37 Mev, while for Sc^{41} they are expected to be unbound since the separation energy for a proton is only 1.63 Mev.[2] Whether or not the difference in the binding of the states has an important effect on their ordering is unclear.

The experimental evidence supporting the existence of the single-particle states is rather scant and comes for the most part from the $Ca^{40}(d,p)Ca^{41}$ reaction.[3] By application of stripping theory to the angular distributions of the resolved proton groups, it is possible to assign the orbital angular momenta of the captured neutrons and by a comparison of the relative cross sections at the maxima of the angular distributions, a distinction can be made between states of mainly single-particle character and those of more complex character. On this basis, the $p_{3/2}$ and $p_{1/2}$ levels have been tentatively assigned at energies of 1.947 and 3.950 Mev, respectively.[4] Seven other levels between 2 and 4 Mev have been assigned l values ($l \leq 2$), but none of these are formed with sufficient intensity to suggest possible single-particle character. In addition, thirteen states in this interval have been located which show no stripping maxima. The data available on the states of Sc^{41} are less complete. States formed by $l=1$ protons in the $Ca^{40}(d,n)Sc^{41}$ reaction have been reported at excitation energies of 1.86 and 2.07 Mev,[5] one of which by analogy with Ca^{41} is probably the $p_{3/2}$ single-particle state. Levels at 2.25 and 3.44 Mev are known from (p,γ) measurements,[6] and at energies above 6 Mev a number of states have been located by the study of the $Ca^{40}(p,p'e^{\pm})Ca^{40}$ reaction.[7]

In the work reported here, additions to the body of information available on Sc^{41} have been made by studying the elastic scattering of protons from Ca^{40}.[8] As is well known, when elastic scattering measurements are made with good resolution, one is able not only to locate excited states of the compound system but also to make spin and parity assignments for the states by an analysis of the resonance shapes. This analysis is much simplified when, as in the case at hand, the target nucleus has zero spin.[9] Another feature of interest in this case results from the low excitation energy with which Sc^{41} can be formed, which enables one to examine much of the energy interval relevant to shell-model considerations.