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ABSTRACT

The $^{85,87}Rb$ relative isotope shift has been investigated by an atomic beam technique and found to be 3.5 ± 0.5 mk. The Rb^{87} $5^2P_{1/2}$ hyperfine structure has also been determined and agrees with previous measurements.

Apparently there has been no accurate determination of the $^{85,87}Rb$ relative isotope shift (RIS). The most reliable estimates are based on early spectroscopic studies of the resonance lines of these isotopes by Kopfermann and Krüger [1] and by Hollenberg [2]. On the basis of these studies Brix and Kopfermann [3] have determined RIS < +3 mk. In the present experiment an atomic beam technique has been used to obtain a more precise measurement of of RIS. The technique has been described previously [4,5] and will be briefly summarized.

An atomic beam apparatus with flop-in geometry is used. The C-region consists of a pair of electric field plates with a gap of 0.035 in. ^{87}Rb atoms (99.16% enriched) from the oven of the atomic beam apparatus are state-selected by the gap so that only atoms in the $m_J = -\frac{1}{2}$ state pass through the C-region. This means that essentially only atoms in the lower hyperfine state, F = 1, can be refocused. Light from an enriched ^{85}Rb (99.54%)

resonance lamp illuminates the region between the electric field plates after filtration by a D_1 interference filter. The lamp line consists of a doublet separated by the ground state hyperfine structure (hfs) of ^{85}Rb, the $^2P_{1/2}$ hfs not being resolved in the lamp. If an electric field is applied across the gap, the transition frequencies of the ^{87}Rb resonance line are decreased by the Stark effect and for certain values of the electric field become equal to the transition frequencies of the ^{85}Rb lines (see fig. 1(a)). Resonance absorption of ^{85}Rb photons by ^{87}Rb atoms then takes place and ^{87}Rb atoms are pumped into the $m_J = +\frac{1}{2}$ and thus $F = 2$ level. These atoms refocus and a signal is observed at the detector. As the electric field is increased from 0 to 380 KV/cm two resonances are observed separated by the ground state hfs of ^{85}Rb. A crude measurement of the RIS can then be obtained from the voltages at which resonances occur, and the hfs of ^{85}Rb and ^{87}Rb. The Stark shift is calibrated by using the same isotope in both the atomic beam apparatus and lamp, and measuring the voltages required to shift through the known ground state hfs of the ^{85}Rb (or ^{87}Rb).

Precision is obtained by filtering the ^{85}Rb D_1 line by a dense beam of Rb in natural abundance. Each resonance is then resolved into two pairs of intensity minima, the separation between pairs equaling the ^{87}Rb $5^2P_{1/2}$ hfs, while the separation within a pair is the ^{85}Rb $5^2P_{1/2}$ hfs (see ref. 5). In the present experiment widths of approximately 200 Mhz were achieved and the RIS could be determined to within 0.5 mk, which is three times the mean error.

An alternative though less satisfactory way to improve the precision is to have the lamp line self reversed. Intensity minima having widths of 400-500 Mhz are obtained in this way. Measurements were made both with an absorption beam and with the line self reversed, and the results show that the position of the resonances was not affected by the increased line width. The roles of the ^{85}Rb and ^{87}Rb were reversed and additional measurements made with consistent results. Typical data is shown in fig. 1(b), (c). The average of 24 determinations yields for the $^{85,87}Rb$ RIS 3.5 ± 0.5 mk with the ^{87}Rb isotope having the higher $(5^2P_{1/2} - 5^2S_{1/2})$ transition frequency. This value is not corrected for the Bohr mass effect which contributes 1.9 mk. In addition the ^{87}Rb $^2P_{1/2}$ hfs has been determined to be 812 ± 15 Mhz in agreement with the results of Rabi and Senitzky [6]. We have used the latter's atomic beam double resonance determination of the $5^2P_{1/2}$ hfs of the Rb isotopes in reducing our data.

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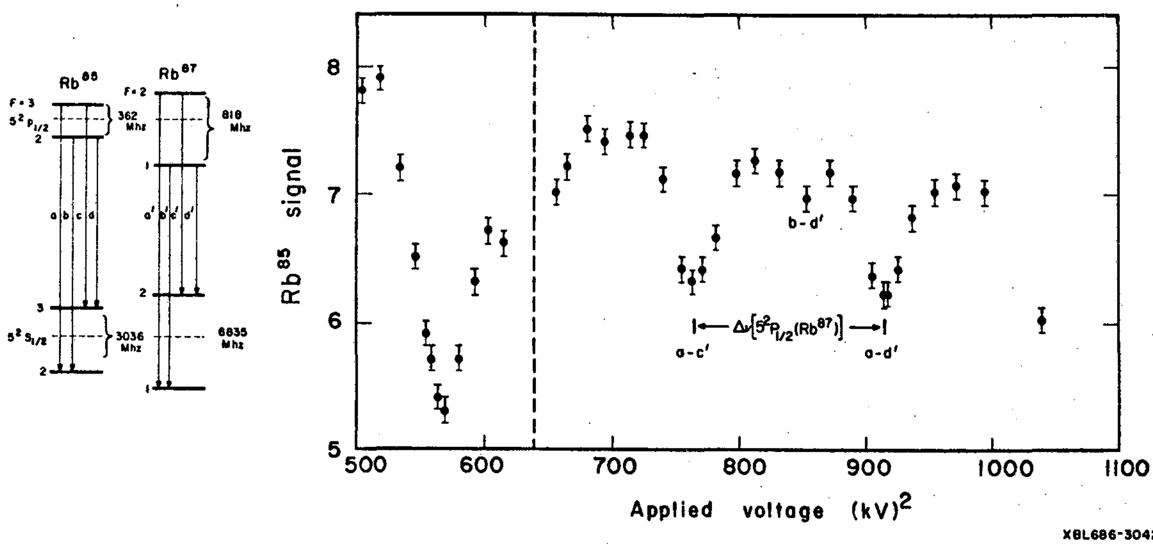
FIGURE CAPTIONS

Fig. 1 (a). When an electric field is applied to ^{87}Rb atoms in the F = 1 state eight coincidences may be obtained between the lines a', b' of ^{87}Rb and a, b, c, d of ^{85}Rb. The Stark shifts required to produce the overlaps are calculated assuming zero RIS and their displacement from the actual overlaps fixes the RIS.

(b). Stark shift calibration using ^{85}Rb lamp and beam. The intensity minima corresponds to simultaneous overlaps b-d and a-c and represents a shift of 3036 Mhz.

(c). Isotope shift data using a ^{87}Rb lamp and a ^{85}Rb beam. Overlaps are indicated on the figure.



Rb85
Rb87
F=3
5²P1/2
2
362 Mhz
F=2
1
816 Mhz
a b c d
a' b' c' d'
3
5²S1/2
2
3036 Mhz
2
1
6835 Mhz
Rb85 signal
Applied voltage (kV)²
b-d'
a-c'
a-d'
Δν[5²P1/2(Rb87)]
XBL686-3042

Fig. 1