

HYPERFINE STRUCTURE SPECTRUM OF THE  $5^3P$  LEVEL OF  $^3\text{He}$   
DETECTED VIA ASSOCIATIVE IONIZATION

S. Runge, A. Pesnelle, M. Perdrix, D. Sevin and G. Watel

Service de Physique des Atomes et des Surfaces, Centre d'Etudes Nucléaires  
de Saclay, 91191 Gif-sur-Yvette Cedex, France

Up to now, most of the experimental investigations on the h.f.s of the Helium atom have been made using different radiofrequency spectroscopy methods. Recently, new optical techniques based on saturated absorption spectroscopy (1) and two photon spectroscopy (2) have been performed on  $^3D(n=3-6)$  and  $^3S(n=4-6)$  levels.

High resolution laser spectroscopy, performed in a crossed beam experiment, is used to obtain h.f.s. spectrum of the ultra violet He  $2^3S$   $5^3P$  transition. The experimental set up consists of a collimated thermal metastable He( $2^3S$ ) beam which collides perpendicularly in the chamber of a quadrupole mass analyzer with a ground state He ( $1^1S$ ) beam. Because of the short lifetime of the  $5^3P$  state, the laser excitation takes place in the He( $2^3S$ ) - He( $1^1S$ ) collision region. Excitation of the He( $5^3P$ ) level from the  $2^3S$  metastable level requires narrow bandwidth UV light at 294.5 nm; this radiation is generated by intracavity frequency doubling a Rhodamine 6G single mode ring dye laser using an ADA crystal as a doubler. The detection of the optical resonances occurring for  $J=0,1,2$  and  $F=1/2, 3/2, 5/2$  is effected by measuring the  $\text{He}_2^+$  associative ions produced in the  $^3\text{He}(5^3P_{J,F}) + ^4\text{He}(1^1S) \rightarrow ^7\text{He}_2^+ + e^-$  collisions (Hornbeck-Molnar process). A mini computer drives the laser frequency and stores in a block memory the ion counts. The fringes of a multipath Fabry Perot interferometer are synchronously recorded.

A typical  $\text{He}_2^+$  ion spectrum is shown in Fig.1, as a function of the UV frequency. It exhibits five of the nine allowed transitions between the  $F=1/2, 3/2$  sublevels of the  $2^3S$  state and the  $F=1/2, 3/2, 5/2$  sublevels of the  $5^3P$  state, which are sufficient to entirely define the h.f.s of the  $5^3P$  state. Mean values for each of the four h.f.s. intervals are deduced from our spectra and are noted in Table I. The uncertainties indicated are equal to a standard deviation.

#### References

- 1) J.E. Lawler, A. I. Ferguson, J.E.M. Goldsmith, D.J. Jackson and A.L. Schawlow, Phys. Rev. Lett 42, 1046 (1979).
- 2) F. Biraben, E.De Clercq, E. Giacobino, G. Grynberg, J. Phys. B 13, L685 (1980).
- 3) M. Maujean and J.P. Descoubes, C.R. Acad. Sci. 264, 1653 (1967).

Fig.1: Hyperfine structure spectrum:  $^3\text{He}^+$  associative ions signal as a function of laser frequency.

- (a) :  $2^3S_1(F = \frac{1}{2}) \rightarrow 5^3P_1(F = \frac{3}{2})$
- (b) :  $2^3S_1(F = \frac{3}{2}) \rightarrow 5^3P_2(F = \frac{5}{2})$
- (c) :  $2^3S_1(F = \frac{3}{2}) \rightarrow 5^3P_2(F = \frac{3}{2})$
- (d) :  $2^3S_1(F = \frac{1}{2}) \rightarrow 5^3P_0(F = \frac{1}{2})$
- (e) :  $2^3S_1(F = \frac{3}{2}) \rightarrow 5^3P_1(F = \frac{1}{2})$

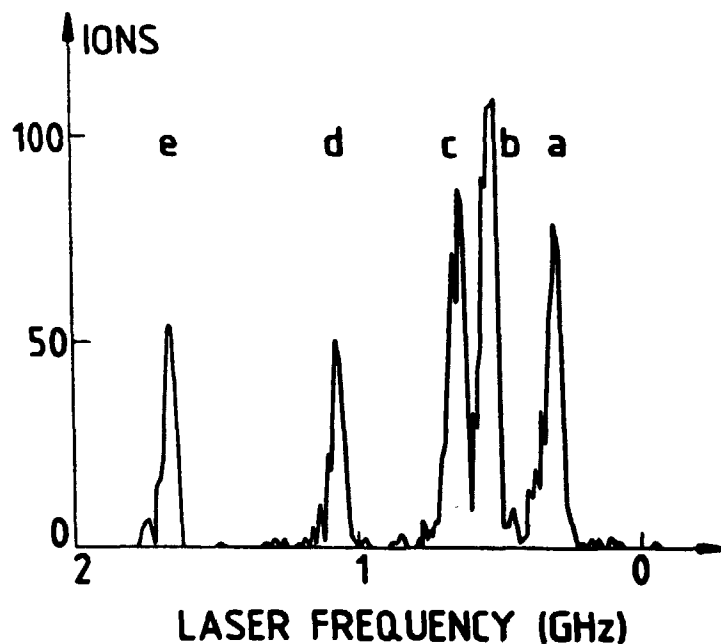


TABLE I : HFS intervals and magnetic dipole coupling constant A which is deduced from them, for the  $5^3P$  state of  $^3\text{He}$ .

Interval (J,F)	$0, \frac{1}{2} \rightarrow 1, \frac{3}{2}$	$1, \frac{3}{2} \rightarrow 1, \frac{1}{2}$	$1, \frac{1}{2} \rightarrow 2, \frac{3}{2}$	$2, \frac{3}{2} \rightarrow 2, \frac{5}{2}$
this work (MHz)	$761 \pm 23$	$5373 \pm 24$	$1030 \pm 16$	$113 \pm 5$
experiment Ref 3(MHz)	$113.5 \pm 0.5$			
$A(5^3P)$ this work	$-4326 \pm 9 \text{ MHz } (-0.1443 \pm 0.0003 \text{ cm}^{-1})$			