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Einstein *A*-coefficients for rotational transitions in the ring-chain isomer of C_5H_2

SURESH CHANDRA and S A SHINDE
School of Physical Sciences, SRTM University, Nanded 431 606, India
E-mail: suresh492000@yahoo.co.in

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Abstract. Laboratory formation of four isomers of C_5H_2 molecule is reported and detection of the ring-chain isomer (isomer 1) of C_5H_2 in cosmic objects has been suggested. For identification of a molecule in cosmic objects, one of the required input data is Einstein A-coefficients (radiative transition probabilities) for the molecule. Here, we report Einstein A-coefficients for electric dipole transitions in the ring-chain isomer of C_5H_2 among the rotational levels of the ground electronic and ground vibrational states up to 21 cm^{-1}.

Keywords. C_5H_2 molecule; molecular data.

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Laboratory formation of four isomers of C_5H_2 molecule is reported [1–3]. The ring-chain isomer (isomer 1) of the molecule, being the most stable one among them, has a rather large probability of its detection in cosmic objects. It is a planar asymmetric top molecule (Ray parametre $\kappa = -0.9803$), and has a large electric dipole moment $\mu = 3.5$ Debye lying in the plane of the molecule and inclined to the axes of inertia so that its components along the a and b axes of inertia are $\mu_a = 2.04$ Debye and $\mu_b = 2.89$ Debye. This isomer, therefore, has both a-type and b-type radiative transitions. The molecular data derived by Travers *et al* [1] for this isomer are given in table 1. Since the temperature in cosmic objects, in general, is rather low only rotational transitions in the ground electronic and ground vibrational states take place.

Table 1. Molecular data.

A (MHz)	34638.7013
B (MHz)	3424.87684
C (MHz)	3113.63865
Δ_J (MHz)	2.888×10^{-4}
Δ_{JK} (MHz)	2.952×10^{-2}
μ_a (Debye)	2.04
μ_b (Debye)	2.89

Table 2. Einstein A-coefficients for a-type *ortho*-rotational transitions in isomer 1 of C_5H_2.

Transition	A-coeff. (s^{-1})	Transition	A-coeff. (s^{-1})	Transition	A-coeff. (s^{-1})
$1_{10} \to 1_{11}$	7.30×10^{-13}	$2_{12} \to 1_{11}$	3.02×10^{-8}	$2_{11} \to 1_{10}$	3.49×10^{-8}
$2_{11} \to 2_{12}$	6.57×10^{-12}	$3_{13} \to 2_{12}$	1.30×10^{-7}	$3_{12} \to 2_{11}$	1.49×10^{-7}
$3_{12} \to 3_{13}$	2.63×10^{-11}	$4_{14} \to 3_{13}$	3.36×10^{-7}	$4_{13} \to 3_{12}$	3.87×10^{-7}
$4_{13} \to 4_{14}$	7.30×10^{-11}	$5_{15} \to 4_{14}$	6.86×10^{-7}	$5_{14} \to 4_{13}$	7.92×10^{-7}
$5_{14} \to 5_{15}$	1.64×10^{-10}	$6_{16} \to 5_{15}$	1.22×10^{-6}	$6_{15} \to 5_{14}$	1.41×10^{-6}
$6_{15} \to 6_{16}$	3.22×10^{-10}	$7_{17} \to 6_{16}$	1.97×10^{-6}	$7_{16} \to 6_{15}$	2.27×10^{-6}
$7_{16} \to 7_{17}$	5.73×10^{-10}	$8_{18} \to 7_{17}$	2.98×10^{-6}	$8_{17} \to 7_{16}$	3.44×10^{-6}
$8_{17} \to 8_{18}$	9.47×10^{-10}	$9_{19} \to 8_{18}$	4.28×10^{-6}	$3_{31} \to 2_{12}$	2.10×10^{-9}
$3_{31} \to 3_{12}$	1.48×10^{-9}	$3_{31} \to 4_{14}$	2.71×10^{-10}	$3_{30} \to 2_{11}$	2.11×10^{-9}
$3_{30} \to 3_{13}$	1.47×10^{-9}	$3_{30} \to 4_{13}$	2.73×10^{-10}	$9_{18} \to 8_{17}$	4.94×10^{-6}
$9_{18} \to 9_{19}$	1.48×10^{-9}	$4_{32} \to 3_{13}$	4.60×10^{-9}	$4_{32} \to 4_{13}$	3.73×10^{-9}
$4_{32} \to 5_{15}$	7.19×10^{-10}	$4_{32} \to 3_{31}$	1.69×10^{-7}	$4_{31} \to 3_{12}$	4.65×10^{-9}
$4_{31} \to 4_{14}$	3.69×10^{-9}	$4_{31} \to 5_{14}$	7.27×10^{-10}	$4_{31} \to 3_{30}$	1.69×10^{-7}
$5_{33} \to 4_{14}$	7.73×10^{-9}	$5_{33} \to 5_{14}$	6.65×10^{-9}	$5_{33} \to 6_{16}$	1.28×10^{-9}
$5_{33} \to 4_{32}$	4.93×10^{-7}	$5_{32} \to 4_{13}$	7.86×10^{-9}	$5_{32} \to 5_{15}$	6.53×10^{-9}
$5_{32} \to 6_{15}$	1.29×10^{-9}	$5_{32} \to 4_{31}$	4.93×10^{-7}	$10_{1,10} \to 9_{19}$	5.91×10^{-6}
$10_{19} \to 9_{18}$	6.82×10^{-6}	$10_{19} \to 10_{1,10}$	2.21×10^{-9}	$6_{34} \to 5_{15}$	1.16×10^{-8}
$6_{34} \to 6_{15}$	1.02×10^{-8}	$6_{34} \to 7_{17}$	1.90×10^{-9}	$6_{34} \to 5_{33}$	1.01×10^{-6}
$6_{33} \to 5_{14}$	1.19×10^{-8}	$6_{33} \to 6_{16}$	9.96×10^{-9}	$6_{33} \to 7_{16}$	1.92×10^{-9}
$6_{33} \to 5_{32}$	1.01×10^{-6}	$11_{1,11} \to 10_{1,10}$	7.91×10^{-6}	$7_{35} \to 6_{16}$	1.64×10^{-8}
$7_{35} \to 7_{16}$	1.44×10^{-8}	$7_{35} \to 8_{18}$	2.54×10^{-9}	$7_{35} \to 6_{34}$	1.77×10^{-6}
$7_{34} \to 6_{15}$	1.70×10^{-8}	$7_{34} \to 7_{17}$	1.39×10^{-8}	$7_{34} \to 8_{17}$	2.57×10^{-9}
$7_{34} \to 6_{33}$	1.77×10^{-6}	$11_{1,10} \to 10_{19}$	9.12×10^{-6}	$11_{1,10} \to 11_{1,11}$	3.19×10^{-9}
$8_{36} \to 7_{17}$	2.21×10^{-8}	$8_{36} \to 8_{17}$	1.93×10^{-8}	$8_{36} \to 9_{19}$	3.18×10^{-9}
$8_{36} \to 7_{35}$	2.81×10^{-6}	$8_{35} \to 7_{16}$	2.33×10^{-8}	$8_{35} \to 8_{18}$	1.85×10^{-8}
$8_{35} \to 9_{18}$	3.19×10^{-9}	$8_{35} \to 7_{34}$	2.81×10^{-6}	$9_{37} \to 8_{18}$	2.89×10^{-8}
$9_{37} \to 9_{18}$	2.48×10^{-8}	$9_{37} \to 10_{110}$	3.79×10^{-9}	$9_{37} \to 8_{36}$	4.16×10^{-6}
$9_{36} \to 8_{17}$	3.10×10^{-8}	$9_{36} \to 9_{19}$	2.35×10^{-8}	$9_{36} \to 10_{19}$	3.78×10^{-9}
$9_{36} \to 8_{35}$	4.16×10^{-6}				

Details for the calculation of Einstein A-coefficients for a-type rotational transitions in an asymmetric top molecule are discussed by Chandra and Sharma [4] and Chandra and Rashmi [5]. By using the data given in table 1, values for a-type rotational transitions in the ground electronic and ground vibrational states of the ring-chain isomer of C_5H_2 among the levels up to 21 cm^{-1} are computed, and are given in tables 2 and 3.

Details for the calculation of Einstein A-coefficients for b-type rotational transitions in an asymmetric top molecule are discussed by Chandra *et al* [6] and Chandra [7]. By using the data given in table 1, values for b-type rotational transitions in the ground electronic and ground vibrational states of the ring-chain isomer of C_5H_2 among the levels up to 21 cm^{-1} are computed, and are given in tables 4 and 5.

The Einstein A-coefficients can be used for computing mean radiative lifetimes of the energy levels [7]. One can easily find out that some pairs of successive levels connected by radiative transitions show that the mean radiative lifetime of the

Table 3. Einstein A-coefficients for a-type *para*-rotational transitions in isomer 1 of C_5H_2.

Transition	A-coeff. (s^{-1})	Transition	A-coeff. (s^{-1})	Transition	A-coeff. (s^{-1})
$1_{01} \to 0_{00}$	4.51×10^{-9}	$2_{02} \to 1_{01}$	4.33×10^{-8}	$3_{03} \to 2_{02}$	1.56×10^{-7}
$4_{04} \to 3_{03}$	3.84×10^{-7}	$5_{05} \to 4_{04}$	7.66×10^{-7}	$6_{06} \to 5_{05}$	1.34×10^{-6}
$2_{21} \to 2_{02}$	1.18×10^{-9}	$2_{20} \to 1_{01}$	9.51×10^{-10}	$2_{20} \to 3_{03}$	2.83×10^{-10}
$3_{22} \to 3_{03}$	2.94×10^{-9}	$3_{22} \to 2_{21}$	8.70×10^{-8}	$3_{21} \to 2_{02}$	2.60×10^{-9}
$3_{21} \to 4_{04}$	6.26×10^{-10}	$3_{21} \to 2_{20}$	8.72×10^{-8}	$7_{07} \to 6_{06}$	2.15×10^{-6}
$4_{23} \to 4_{04}$	5.30×10^{-9}	$4_{23} \to 3_{22}$	2.89×10^{-7}	$4_{22} \to 3_{03}$	5.19×10^{-9}
$4_{22} \to 5_{05}$	9.52×10^{-10}	$4_{22} \to 3_{21}$	2.90×10^{-7}	$5_{24} \to 5_{05}$	8.24×10^{-9}
$5_{24} \to 4_{23}$	6.46×10^{-7}	$5_{23} \to 4_{04}$	9.00×10^{-9}	$5_{23} \to 6_{06}$	1.22×10^{-9}
$5_{23} \to 4_{22}$	6.49×10^{-7}	$8_{08} \to 7_{07}$	3.23×10^{-6}	$6_{25} \to 6_{06}$	1.18×10^{-8}
$6_{25} \to 5_{24}$	1.20×10^{-6}	$6_{24} \to 5_{05}$	1.43×10^{-8}	$6_{24} \to 7_{07}$	1.40×10^{-9}
$6_{24} \to 5_{23}$	1.21×10^{-6}	$9_{09} \to 8_{08}$	4.61×10^{-6}	$7_{26} \to 7_{07}$	1.59×10^{-8}
$7_{26} \to 6_{25}$	1.99×10^{-6}	$7_{25} \to 6_{06}$	2.14×10^{-8}	$7_{25} \to 8_{08}$	1.48×10^{-9}
$7_{25} \to 6_{24}$	2.00×10^{-6}	$10_{0,10} \to 9_{09}$	6.33×10^{-6}	$8_{27} \to 8_{08}$	2.06×10^{-8}
$8_{27} \to 7_{26}$	3.05×10^{-6}	$8_{26} \to 7_{07}$	3.07×10^{-8}	$8_{26} \to 9_{09}$	1.47×10^{-9}
$8_{26} \to 7_{25}$	3.09×10^{-6}	$8_{26} \to 8_{27}$	3.05×10^{-13}	$9_{28} \to 9_{09}$	2.59×10^{-8}
$9_{28} \to 8_{27}$	4.43×10^{-6}	$9_{27} \to 8_{08}$	4.26×10^{-8}	$9_{27} \to 10_{0,10}$	1.39×10^{-9}
$9_{27} \to 8_{26}$	4.50×10^{-6}	$9_{27} \to 9_{28}$	9.41×10^{-13}	$11_{0,11} \to 10_{0,10}$	8.43×10^{-6}
$10_{29} \to 10_{0,10}$	3.18×10^{-8}	$10_{29} \to 9_{28}$	6.17×10^{-6}	$10_{28} \to 9_{09}$	5.72×10^{-8}
$10_{28} \to 9_{27}$	6.28×10^{-6}	$10_{28} \to 11_{0,11}$	1.25×10^{-9}	$10_{28} \to 10_{29}$	2.57×10^{-12}
$11_{2,10} \to 11_{0,11}$	3.82×10^{-8}	$11_{2,10} \to 10_{29}$	8.30×10^{-6}	$11_{29} \to 10_{0,10}$	7.49×10^{-8}
$11_{29} \to 10_{28}$	8.48×10^{-6}	$11_{29} \to 11_{2,10}$	6.36×10^{-12}	$4_{41} \to 4_{04}$	4.05×10^{-13}
$4_{41} \to 3_{22}$	5.04×10^{-9}	$4_{41} \to 4_{22}$	2.47×10^{-9}	$4_{41} \to 5_{24}$	3.59×10^{-10}
$4_{40} \to 3_{03}$	2.62×10^{-13}	$4_{40} \to 5_{05}$	1.47×10^{-13}	$4_{40} \to 3_{21}$	5.04×10^{-9}
$4_{40} \to 4_{23}$	2.47×10^{-9}	$4_{40} \to 5_{23}$	3.58×10^{-10}	$5_{42} \to 5_{05}$	2.43×10^{-12}
$5_{42} \to 4_{23}$	1.04×10^{-8}	$5_{42} \to 5_{23}$	6.36×10^{-9}	$5_{42} \to 6_{25}$	1.04×10^{-9}
$5_{42} \to 4_{41}$	2.77×10^{-7}	$5_{41} \to 4_{04}$	1.60×10^{-12}	$5_{41} \to 6_{06}$	8.63×10^{-13}
$5_{41} \to 4_{22}$	1.04×10^{-8}	$5_{41} \to 5_{24}$	6.36×10^{-9}	$5_{41} \to 6_{24}$	1.04×10^{-9}
$5_{41} \to 4_{40}$	2.77×10^{-7}				

Table 4. Einstein A-coefficients for b-type *ortho*-rotational transitions in isomer 1 of C_5H_2.

Transition	A-coeff. (s^{-1})	Transition	A-coeff. (s^{-1})	Transition	A-coeff. (s^{-1})
$1_{10} \to 1_{01}$	1.52×10^{-6}	$2_{12} \to 1_{01}$	2.48×10^{-6}	$2_{21} \to 1_{10}$	3.58×10^{-5}
$2_{21} \to 2_{12}$	1.37×10^{-5}	$2_{12} \to 3_{03}$	2.87×10^{-8}	$2_{21} \to 3_{12}$	1.31×10^{-6}
$3_{21} \to 2_{12}$	3.40×10^{-5}	$3_{30} \to 2_{21}$	1.91×10^{-4}	$3_{12} \to 3_{03}$	1.62×10^{-6}
$3_{21} \to 3_{12}$	1.68×10^{-5}	$3_{30} \to 3_{03}$	6.34×10^{-9}	$3_{30} \to 3_{21}$	4.72×10^{-5}
$3_{21} \to 4_{14}$	1.71×10^{-6}	$3_{30} \to 4_{23}$	3.89×10^{-6}	$4_{14} \to 3_{03}$	4.77×10^{-6}
$4_{23} \to 3_{12}$	3.45×10^{-5}	$4_{32} \to 3_{03}$	1.93×10^{-8}	$4_{32} \to 3_{21}$	1.73×10^{-4}
$4_{41} \to 3_{12}$	3.01×10^{-9}	$4_{41} \to 3_{30}$	5.61×10^{-4}	$4_{23} \to 4_{14}$	1.90×10^{-5}
$4_{32} \to 4_{23}$	6.62×10^{-5}	$4_{41} \to 4_{14}$	2.70×10^{-9}	$4_{41} \to 4_{32}$	1.04×10^{-4}

Table 4. (Continued).

Transition	A-coeff. (s^{-1})	Transition	A-coeff. (s^{-1})	Transition	A-coeff. (s^{-1})
$4_{23} \to 5_{14}$	1.38×10^{-6}	$4_{32} \to 5_{05}$	8.17×10^{-9}	$4_{32} \to 5_{23}$	6.21×10^{-6}
$4_{41} \to 5_{14}$	6.68×10^{-10}	$4_{41} \to 5_{32}$	7.08×10^{-6}	$5_{05} \to 4_{14}$	4.10×10^{-10}
$5_{23} \to 4_{14}$	3.75×10^{-5}	$5_{32} \to 4_{23}$	1.67×10^{-4}	$5_{41} \to 4_{14}$	1.08×10^{-8}
$5_{41} \to 4_{32}$	5.10×10^{-4}	$5_{14} \to 5_{05}$	1.81×10^{-6}	$5_{23} \to 5_{14}$	1.86×10^{-5}
$5_{32} \to 5_{05}$	7.09×10^{-8}	$5_{32} \to 5_{23}$	7.57×10^{-5}	$5_{41} \to 5_{14}$	1.12×10^{-8}
$5_{41} \to 5_{32}$	1.55×10^{-4}	$5_{23} \to 6_{16}$	1.37×10^{-6}	$5_{32} \to 6_{25}$	7.21×10^{-6}
$5_{41} \to 6_{16}$	2.66×10^{-9}	$5_{41} \to 6_{34}$	1.30×10^{-5}	$6_{16} \to 5_{05}$	8.20×10^{-6}
$6_{25} \to 5_{14}$	3.95×10^{-5}	$6_{34} \to 5_{05}$	1.21×10^{-7}	$6_{34} \to 5_{23}$	1.67×10^{-4}
$6_{25} \to 6_{16}$	2.09×10^{-5}	$6_{34} \to 6_{25}$	8.14×10^{-5}	$6_{25} \to 7_{16}$	7.23×10^{-7}
$6_{34} \to 7_{07}$	4.11×10^{-8}	$6_{34} \to 7_{25}$	7.28×10^{-6}	$7_{07} \to 6_{16}$	1.12×10^{-7}
$7_{25} \to 6_{16}$	4.47×10^{-5}	$7_{34} \to 6_{25}$	1.71×10^{-4}	$7_{16} \to 7_{07}$	2.11×10^{-6}
$7_{25} \to 7_{16}$	1.90×10^{-5}	$7_{34} \to 7_{07}$	2.83×10^{-7}	$7_{34} \to 7_{25}$	8.47×10^{-5}
$7_{25} \to 8_{18}$	8.24×10^{-7}	$7_{34} \to 8_{27}$	6.94×10^{-6}	$8_{18} \to 7_{07}$	1.30×10^{-5}
$8_{27} \to 7_{16}$	4.70×10^{-5}	$8_{36} \to 7_{07}$	4.27×10^{-7}	$8_{36} \to 7_{25}$	1.76×10^{-4}
$8_{27} \to 8_{18}$	2.25×10^{-5}	$8_{36} \to 8_{27}$	8.77×10^{-5}	$8_{27} \to 9_{18}$	2.21×10^{-7}
$8_{36} \to 9_{09}$	1.12×10^{-7}	$8_{36} \to 9_{27}$	6.15×10^{-6}	$9_{09} \to 8_{18}$	7.92×10^{-7}
$9_{27} \to 8_{18}$	5.36×10^{-5}	$9_{36} \to 8_{27}$	1.84×10^{-4}	$9_{18} \to 9_{09}$	2.56×10^{-6}
$9_{27} \to 9_{18}$	1.89×10^{-5}	$9_{36} \to 9_{09}$	7.68×10^{-7}	$9_{36} \to 9_{27}$	8.86×10^{-5}
$9_{27} \to 10_{1,10}$	4.23×10^{-7}	$9_{36} \to 10_{29}$	5.47×10^{-6}	$10_{1,10} \to 9_{09}$	1.93×10^{-5}
$10_{29} \to 9_{18}$	5.61×10^{-5}	$10_{29} \to 10_{1,10}$	2.43×10^{-5}	$10_{29} \to 11_{1,10}$	1.90×10^{-8}
$11_{0,11} \to 10_{1,10}$	2.73×10^{-6}	$11_{29} \to 10_{1,10}$	6.37×10^{-5}	$11_{1,10} \to 11_{0,11}$	3.22×10^{-6}
$11_{29} \to 11_{1,10}$	1.86×10^{-5}				

Table 5. Einstein A-coefficients for b-type *para*-rotational transitions in isomer 1 of C_5H_2.

Transition	A-coeff. (s^{-1})	Transition	A-coeff. (s^{-1})	Transition	A-coeff. (s^{-1})
$1_{11} \to 0_{00}$	1.74×10^{-6}	$1_{11} \to 2_{02}$	9.81×10^{-8}	$2_{20} \to 1_{11}$	3.59×10^{-5}
$2_{11} \to 2_{02}$	1.56×10^{-6}	$2_{20} \to 2_{11}$	1.35×10^{-5}	$2_{20} \to 3_{13}$	1.38×10^{-6}
$3_{13} \to 2_{02}$	3.49×10^{-6}	$3_{22} \to 2_{11}$	3.36×10^{-5}	$3_{31} \to 2_{02}$	4.43×10^{-9}
$3_{31} \to 2_{20}$	1.91×10^{-4}	$3_{22} \to 3_{13}$	1.73×10^{-5}	$3_{31} \to 3_{22}$	4.72×10^{-5}
$3_{13} \to 4_{04}$	1.74×10^{-9}	$3_{22} \to 4_{13}$	1.57×10^{-6}	$3_{31} \to 4_{04}$	2.03×10^{-9}
$3_{31} \to 4_{22}$	3.89×10^{-6}	$4_{22} \to 3_{13}$	3.51×10^{-5}	$4_{31} \to 3_{22}$	1.73×10^{-4}
$4_{40} \to 3_{13}$	2.96×10^{-9}	$4_{40} \to 3_{31}$	5.61×10^{-4}	$4_{13} \to 4_{04}$	1.70×10^{-6}
$4_{22} \to 4_{13}$	1.81×10^{-5}	$4_{31} \to 4_{04}$	2.66×10^{-8}	$4_{31} \to 4_{22}$	6.61×10^{-5}
$4_{40} \to 4_{13}$	2.78×10^{-9}	$4_{40} \to 4_{31}$	1.04×10^{-4}	$4_{22} \to 5_{15}$	1.62×10^{-6}
$4_{31} \to 5_{24}$	6.23×10^{-6}	$4_{40} \to 5_{15}$	6.40×10^{-10}	$4_{40} \to 5_{33}$	7.08×10^{-6}
$5_{15} \to 4_{04}$	6.33×10^{-6}	$5_{24} \to 4_{13}$	3.66×10^{-5}	$5_{33} \to 4_{04}$	5.38×10^{-8}
$5_{33} \to 4_{22}$	1.67×10^{-4}	$5_{42} \to 4_{13}$	1.11×10^{-8}	$5_{42} \to 4_{31}$	5.10×10^{-4}
$5_{24} \to 5_{15}$	2.01×10^{-5}	$5_{33} \to 5_{24}$	7.58×10^{-5}	$5_{42} \to 5_{15}$	1.07×10^{-8}
$5_{42} \to 5_{33}$	1.55×10^{-4}	$5_{24} \to 6_{15}$	1.06×10^{-6}	$5_{33} \to 6_{06}$	2.05×10^{-8}
$5_{33} \to 6_{24}$	7.18×10^{-6}	$5_{42} \to 6_{15}$	2.82×10^{-9}	$5_{42} \to 6_{33}$	1.30×10^{-5}

Table 5. (Continued).

Transition	A-coeff. (s^{-1})	Transition	A-coeff. (s^{-1})	Transition	A-coeff. (s^{-1})
$6_{06} \to 5_{15}$	2.03×10^{-8}	$6_{24} \to 5_{15}$	4.08×10^{-5}	$6_{33} \to 5_{24}$	1.67×10^{-4}
$6_{15} \to 6_{06}$	1.94×10^{-6}	$6_{24} \to 6_{15}$	1.89×10^{-5}	$6_{33} \to 6_{06}$	1.52×10^{-7}
$6_{33} \to 6_{24}$	8.12×10^{-5}	$6_{24} \to 7_{17}$	1.09×10^{-6}	$6_{33} \to 7_{26}$	7.33×10^{-6}
$7_{17} \to 6_{06}$	1.04×10^{-5}	$7_{26} \to 6_{15}$	4.30×10^{-5}	$7_{35} \to 6_{06}$	2.38×10^{-7}
$7_{35} \to 6_{24}$	1.71×10^{-4}	$7_{26} \to 7_{17}$	2.17×10^{-5}	$7_{35} \to 7_{26}$	8.51×10^{-5}
$7_{26} \to 8_{17}$	4.35×10^{-7}	$7_{35} \to 8_{08}$	7.13×10^{-8}	$7_{35} \to 8_{26}$	6.86×10^{-6}
$8_{08} \to 7_{17}$	3.42×10^{-7}	$8_{26} \to 7_{17}$	4.90×10^{-5}	$8_{35} \to 7_{26}$	1.77×10^{-4}
$8_{17} \to 8_{08}$	2.31×10^{-6}	$8_{26} \to 8_{17}$	1.89×10^{-5}	$8_{35} \to 8_{08}$	4.83×10^{-7}
$8_{35} \to 8_{26}$	8.70×10^{-5}	$8_{26} \to 9_{19}$	6.01×10^{-7}	$8_{35} \to 9_{28}$	6.28×10^{-6}
$9_{19} \to 8_{08}$	1.59×10^{-5}	$9_{28} \to 8_{17}$	5.14×10^{-5}	$9_{37} \to 8_{08}$	7.17×10^{-7}
$9_{37} \to 8_{26}$	1.83×10^{-4}	$9_{28} \to 9_{19}$	2.34×10^{-5}	$9_{37} \to 9_{28}$	8.96×10^{-5}
$9_{28} \to 10_{19}$	8.53×10^{-8}	$9_{37} \to 10_{0,10}$	1.64×10^{-7}	$9_{37} \to 10_{28}$	5.30×10^{-6}
$10_{0,10} \to 9_{19}$	1.55×10^{-6}	$10_{28} \to 9_{19}$	5.86×10^{-5}	$10_{19} \to 10_{0,10}$	2.86×10^{-6}
$10_{28} \to 10_{19}$	1.88×10^{-5}	$10_{28} \to 11_{1,11}$	2.88×10^{-7}	$11_{1,11} \to 10_{0,10}$	2.32×10^{-5}
$11_{2,10} \to 10_{19}$	6.13×10^{-5}	$11_{2,10} \to 11_{1,11}$	2.53×10^{-5}		

upper level is larger than that of the lower one. The transition $5_{05} \to 4_{14}$ shows that radiative lifetime of the upper level 5_{05} is 6.7 times larger than that of the lower level 4_{14}, and the Einstein A-coefficient for the transition is 4.10×10^{-10} s^{-1}. Larger value of radiative lifetime of the upper level than that of the lower one support the idea of population inversion which leads to the maser action. Treatment of this isomer is quite complicated as there are both a-type and b-type radiative transitions.

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