MICROWAVE SPECTROSCOPY OF THE CALCIUM $4s nf \rightarrow 4s(n + 1)d, 4sng, 4snh, 4sni, \text{ AND } 4s nk$ TRANSITIONS

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We use a delayed field ionization technique to observe the microwave transitions of calcium Rydberg states, from the $4s nf$ states to the $4s(n + 1)d, 4sng, 4snh, 4sni$, and $4s nk$ states for $18 \leq n \leq 23$. We analyze the observed intervals between the $\ell$ and $(\ell + 1), \ell \geq 5$, states of the same $n$ to determine the Ca$^+$ $4s$ dipole and quadrupole polarizabilities. We show that the adiabatic core polarization model is not adequate to extract the Ca$^+$ $4s$ dipole and quadrupole polarizabilities and a non adiabatic treatment is required. We use the non adiabatic core polarization model to determine the ionic dipole and quadrupole polarizabilities to be $\alpha_d = 76.9(3) \ a_0^3$ and $\alpha_q = 206(9) \ a_0^5$, respectively.