Giant atoms interacting with radiation

Serge Haroche

(Laboratoire de Physique de 1'Ecole Normale Superieure)
24 rue Lhomond, 75231 Paris Cedex 05, France (Tel.: 707 42.00)

Rydberg atoms are atoms in which the valence electron has been excited to a very big orbital corresponding to a large value of the principal quantum number n. The preparation and study of these "giant atoms" have been made possible by the development of tunable lasers which allow us to selectively excite from a ground or a metastable state, in one- or multiple-step, any Rydberg level of given n ($10 \lesssim n \lesssim 100$) and l angular quantum number. The properties of these species are quite different from those of ordinary ground-state or moderately excited atomic systems, which makes the physics of these atoms quite attractive and explains the recent interest in their study. At Ecole Normale Superieure in Paris, we are investigating in particular the radiative properties of these atoms. Due to their huge electric dipole matrix elements connecting nearly states, these atoms are very sensitive to resonant millimeter wave rediation. Furthermore, the radiative lifetime of Rybderg states is very long. These characteristics have allowed us to perform, with extremely low microwave power, very high resolution ($\sim 10^8$) microwave spectroscopy on these atoms. These experiments have interesting possible applications in metrology. The sensitivity of these giant atoms to microwaves is such that maser action between Rydberg levels can be easily achieved with inversion thresholds as low as 10^3–10^4 atoms only. The study of these very small masers seems to be very promising in fundamental physics and for the development of far infrared and millimeter waves amplifiers and detectors as well.

巨原子与辐射的相互作用

Serge Haroche

(法国高等师范学院物理实验室)

里德伯原子是指其价电子被激发到相当于主量子数n很大的轨道上的原子，由于可调谐激光器的进展，我们可能通过一步或者多步从基态或者亚稳态有选择地激发到具有一定n ($10 \leqslant n \leqslant 100$)和角量子数$l$的任一里德伯态上，这样就有可能制备及研究这些"巨原子"。这些样品的性质与那些具有一般基态或中等程度激励的原子体系的性质十分不同，因而使得这些原子的物理问题十分引人注意，这也说明了近来对这项研究的重视。在巴黎高等师范学校里，我们特别研究了这些原子的辐射性质。由于联结的相邻状态之间有极大的电偶极矩阵元，这些原子对毫米波引起的共振是十分灵敏的。此外，里德伯态的辐射寿命很长。这些特点允许我们以极低的微波功率对这些原子进行分辨率极高 ($\sim 10^8$) 的微波光谱学研究。这些实验在计量学中有引人注意而可能的应用。这些巨原子对微波的灵敏度是，当反转阈值低到只有$10^3 \sim 10^4$原子时也能够很容易地获得微波激射作用。对这些微小的微波激射器的研究似乎在基本物理方面以及在发展远红外和毫米波放大器和探测器方面是十分有前途的。