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论文

溴甲烷在强激光场中的电离和解离

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摘要:

利用自制的反射式飞行时间质谱仪(RTOF-MS)研究了多原子分子CH_3Br在强激光场中的电离解离. 得到了溴甲烷在强激光场中电离解离的飞行时间质谱, 基于RTOF-MS的高分辨率($M/\Delta M>2000$), 测量了分子库仑爆炸产生的系列碎片离子的动能释放(KER), 用多光子解离和库仑爆炸解释了实验结果. 与碘甲烷在强场中的实验结果对比发现: (1) 在相同的激光场强下, 碘甲烷电离解离的最高价碎片离子为I^{6+}而溴甲烷为Br^{3+}; (2) 溴甲烷质谱中存在母体离子的脱氢产物CH_mBr^+ 和CH_mBr^{2+}, 而对于碘甲烷, 没有检测到这些通道, C—I键首先断开; (3) 质谱中存在$H^{79}Br^+$和$H^{81}Br^+$, 而碘甲烷的电离解离中不存在HI产物; (4) 溴甲烷库仑两体爆炸的有效电荷间距随着两碎片电荷乘积的增大而增大, 而对于碘甲烷此间距几乎不随电荷乘积变化; (5) CH_m^+($m=0, 1, 2$)的主要生成通道可能与碘甲烷不同, 不是来自CH_3^+的顺序脱氢, 而是来自脱氢母体离子的直接解离.

关键词: 飞行时间质谱; 强激光场; 库仑爆炸; 多光子解离

Ionization and Dissociation of Methyl Bromide in Intense Laser Field

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Abstract:

Ionization-dissociation of methyl bromide in intense laser field was studied using home-built reflection time-of-flight mass spectrometer. Based on the relative high resolution of the RTOF-MS($M/\Delta M>2000$), the Kinetic Energy Release(KER) of the fragment ions was measured. Multiphoton dissociation and Coulomb explosion mechanisms were used to explain the experimental results. Comparing with the result of methyl iodide in intense laser field, some differences are observed: (1) at the same laser field intensity, the highest charged fragment ion of methyl bromide was Br^{3+}, lower than I^{6+} of methyl iodide; (2) the dehydrogenation channel was observed in the multiphoton dissociation or Coulomb explosion of methyl bromide, but was not observed in the case of methyl iodide; (3) HBr^+ was observed, but there was no similar channel in the case of methyl iodide; (4) for methyl bromide, the valid charge distance of Coulomb explosion increases with the product of p and q; while in the case of methyl iodide, the distance remained almost the same; (5) the producing channel of CH_m^+($m=0, 1, 2$) is different from the ionization-dissociation of methyl iodide in which the stepwise dissociation of CH_3^+ was thought to be the main channel, CH_m^+($m=0, 1, 2$) of methyl bromide are mainly from the products of the direct dissociation of the dehydrogenated parent ions instead of the stepwise dissociation of CH_3^+.

Keywords: Time-of-flight mass spectrometry; Intense laser field; Coulomb explosion; Multiphoton dissociation

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