论文

圆锥泡声致发光气泡动力学过程的理论分析

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摘要　　在绝热压缩模型的基础上，详细讨论了圆锥泡声致发光中气泡运动的动力学过程，得到了气泡塌陷速度方程、气泡内压强方程以及温度方程. 结果显示在气泡进入圆锥腔的初始阶段，气泡的塌陷速度随着压缩半径的不断减小近似线性地增加；然后随着压缩半径的进一步减小，气泡塌陷的加速度逐渐减小；当气泡塌陷速度达到最大值后，随着气泡压缩半径的进一步减小，塌陷速度迅速下降至零. 在假设初始气压为 $1000\,Pa$ 的基础上，理论分析得到气泡的最高塌陷速度可以达到 $5.8\,m/s$；气泡的最小压缩半径可以达到 $1.37\,cm$，相应的气泡内极限压强超过 $4.5\times 10^5\,Pa$，极限温度超过 $3\,150\,K$，而液流能够提供给气泡的能量达到 $0.02\,J$. 理论推导得到的结果可以比较好地用来解释实验中的现象. 最后分析得到气泡内的初始气压对气泡所能达到的极端条件有着重要的影响.

关键词　　圆锥泡声致发光　塌陷速度方程　绝热压缩　压缩半径　压强

分类号　0354

Theory of the dynamics process of the conical bubble sonoluminescence

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Abstract

The dynamics process of the conical bubble sonoluminescence has been discussed based on the adiabatic process. The equations of velocity of bubble collapse, the pressure and temperature within the bubble have been achieved. Result show the velocity of collapsing bubble approximately linearly increases with the decrease of the radius of collapsing bubble firstly, then the maximal velocity of collapsing bubble can be achieved, subsequently the velocity of collapsing bubble quickly decreases. Based on the supposition of initial pressure equal to $1\,000\,Pa$, the maximal value of the velocity of bubble collapse reaches $5.8\,m/s$, the minimum radius of the bubble is $1.37\,cm$, then the huge pressure of 4.5×10^5 $\,Pa$, the collapsing temperature above $37\,000\,K$, and the maximal energy about $0.02\,J$ providing to the bubble can be achieved. The equations obtained in this paper could explain the phenomena of experiment. Finally, results show that the initial pressure within the bubble has important effects on the final extreme conditions.

Key words　conical bubble sonoluminescence　equation of velocity of collapsing bubble　adiabatic collapse　radius of collapsing bubble　pressure

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