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# 基于拉格朗日力学的伞-弹系统动力学模型

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# Dynamic Model of Parachute-projectile Systems Based on Lagrange Mechanics

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**摘要** 为了回避牛顿力学体系在多体动力学建模过程中存在的复杂约束力求解问题，以拉格朗日力学体系为基础，从分析力学的角度出发，建立了铅垂平面内降落伞-弹系统五自由度动力学模型。详细介绍了拉格朗日力学体系动力学建模过程，推导了铅垂平面内伞-弹系统动能公式，解决了伞-弹系统广义力求解问题，给出了伞-弹所受空气动力的广义力表示。算例将建立的伞-弹系统模型和牛顿力学体系下简化的伞-弹模型进行对比，两种模型计算结果吻合，验证了本文模型的正确性。降落伞-弹系统动力学模型验证了拉格朗日力学在常规飞行器动力学建模中的可行性，为使用ADAMS等基于拉格朗日力学思想建模的商业软件进行伞-弹系统动力学求解提供理论依据，可以用于指导伞-弹系统的分析和设计。

**关键词：** 降落伞 多体动力学 拉格朗日力学 飞行力学 外弹道学

Abstract： Based on Lagrange mechanics and starting from analytical mechanics, a five degree-of-freedom dynamic model of the terminal descent of a parachute projectile system is developed. Compared with the parachute system models based on Newton mechanics, this model is better for multi body dynamics, for the solution of binding forces between the parachute and the projectile is avoided. The Lagrange mechanics modeling process is introduced in detail. The parachute projectile system's kinetic energy equation is deduced and the generalized forces are solved. Through an example, the validity of the model is verified by comparing the parachute projectile dynamic models based on Lagrange mechanics and Newton mechanics. The feasibility of the flight vehicle dynamic modeling process based on Lagrange mechanics is verified, which provides theoretical basis of using ADAMS to solve the parachute projectile system dynamics problems. This method can be used in the parachute-projectile system analysis and design.

Keywords： parachutes multi-body dynamics Lagrange mechanics flight dynamics exterior ballistics

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