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基于Fabry-Perot的中高层大气风速反演数据处理研究

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Data processing of the middle and upper atmospheric wind field retrieval based on the Fabry-Perot Interferometer

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摘要

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摘要

中高层大气风速反演需要精确的确定法布里-帕罗干涉仪(Fabry-Perot Interferometer, FPI)干涉条纹的圆心和半径. 本文针对FPI非闭合式干涉环条纹, 提出了新的条纹圆心和半径确定方法: 首先对所得到的条纹强度分布进行噪声去除预处理: 包括均值滤波和自适应滤波; 然后初步确定圆心, 以该圆心为中心作 n 条射线得到 n 条干涉环剖面, 利用高斯函数拟合得到干涉环峰值位置, 再利用所得峰值位置进行圆拟合得到新的圆心和半径; 最后以新的圆心为初始圆心重复上述计算过程直到圆心坐标收敛. 利用上述方法对FPI仿真数据进行处理, 并用于中高层大气风速反演, 得到风速值为96.9537 m/s(对应实际风速值约100 m/s)和7.528.2 m/s (对应实际风速值约10 m/s), 将其与理论实际值进行比较, 得到反演绝对误差分别为-2.977 m/s和-2.465 m/s, 相对误差分别为-2.98%和-24.67%, 表明上述方法满足中高层大气风速(一般为每秒几十米到几百米)的反演精度要求, 初步论证了圆心和半径确定方法的可行性.

关键词 Fabry-Perot干涉仪(FPI), 中高层大气, 风速反演, 非闭合式干涉环

Abstract:

The accurate estimation of center coordinates and radius of Fabry-Perot Interferometer (FPI) interference fringes can retrieve an accurate wind velocity of the middle and upper atmosphere. In this paper, a new method is proposed for the center coordinates and radius estimation of non-closed interference fringes of FPI. After denoising processing of the fringe intensity including mean filtering and adaptive filtering, cross sections are taken with the pole at the center of the interference fringes. Interference fringe peak coordinates are acquired according to the Gauss distribution of fringe intensity. Then, new center coordinates and radius are estimated by using circle fitting with the least square method. Finally, center coordinate and radius can be calculated through the iterative operation. The new method was applied to Fabry-Perot interferometer data processing for wind velocity estimation of the middle and upper atmosphere. Wind velocity retrievals are 96.9537 m/s (actual wind velocity ~100 m/s) and 7.528.2 m/s (actual wind velocity ~10 m/s). Compared with actual values, the retrieval values are lower by 2.977 m/s and 2.465 m/s respectively. Relative errors are -2.98% and -24.67% respectively, which suggests a tentatively reliable and practicable method of circle center and radius estimation for wind velocity retrieval of upper atmosphere (from scores of meters to hundreds meters per second).

Keywords Fabry-Perot Interferometer (FPI), The middle and upper atmosphere, Wind velocity retrieval, Non-closed interference fringes

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