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## 基于尺度变换随机共振的瞬变电磁弱信号检测

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Scale transformation for detecting transient electromagnetic weak signal of stochastic resonance

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摘要

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**摘要** 晚期瞬变电磁信号是大参数、多频率、且各频率分量未知的电磁信号,特别在晚期还是强噪声背景下的微弱信号.随机共振系统可以在极限信噪比的情况下提取微弱信号,但仅适用于小参数、单一频率或频率已知的高频信号的情况.为此,本文提出一种基于尺度变换的随机共振算法用于检测晚期瞬变电磁信号,该方法充分利用了随机共振检测弱信号的优势,通过引入尺度变换,消除了随机共振系统对待测信号频率的限制,在绝热近似理论下,实现了从强噪声中提取出微弱晚期瞬变电磁目标信号.理论分析和仿真结果表明:对埋在强噪声中的未知频率的晚期瞬变电磁信号,采用连续的压缩算法,以获得一个适当的输入信号到随机共振体系,根据输出信号共振谱峰的变化,经反变换运算可得待测弱晚期瞬变电磁信号的各个未知频率,各个频率的叠加即可还原晚期瞬变电磁信号.与传统方法相比,本方法数据采集量和采集时间都减小到原来的几分之一,能在极限信噪比(信噪比-50 dB)下,提取出目标信号,为获得深层目标信号提供了可能,从而提高了瞬变电磁探测仪器的探测深度和探测精度.

**关键词:** 随机共振 尺度变换 瞬变电磁 弱信号检测

**Abstract:** Transient Electromagnetic (TEM) signal is a large-parameter, multi-frequency signal with unknown frequency, which is weak under heavy noise in the late stage. Stochastic resonance (SR) can only be applied to small parameters, low-frequency or the known high-frequency signal detection. To solve this problem, a scale transformation for detecting TEM weak periodic signal of SR method is presented in this paper. The method is benefited from SR for detecting weak signals. The frequency limit of SR is eliminated by introducing scale transformation. The TEM weak signal is detected from heavy noise under the condition of adiabatic approximation. Theoretical analysis and simulation results show that, to deal with the unknown TEM signal mixed with heavy noise, the frequency of input signal is compressed continuously to achieve a suitable frequency for inputting to stochastic resonance system. According to the change of resonance spectral peak value, the unknown TEM frequencies can be obtained from signal with inverse transform algorithm. Compared with traditional methods, the data collection and the acquisition time is reduced ten times. The deep target signal is detected under limit SNR (SNR≤-50 dB). The detection accuracy and investigation depth of the instrument is increased by this method.

**Keywords:** Stochastic resonance Scale transformation Transient electromagnetic Weak signal detection

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