# Nonlinear reconstruction of pulse noisy images via stochastic resonance

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Recently, the pulse images have been widely used in optical processing due to the low power required and energy loss in long distance transmission. It has shown a large number of potential applications in different areas of technology, such as laser radar, space optical communication and optical remote sensing. However, in many imaging fields above, a low-level signal image is often merged by the scattering noise and difficult to be distinguished by the traditional detection methods. While in nonlinear systems, an appropriate level of noise is benefit to recover signal because of a more complex dynamics described as "stochastic resonance (SR)". The signal can be effectively reconstructed and amplified from a low input signal-to-noise intensity ratio, which cannot be achieved in conventional linear systems. In addition, this effect is also applied to the signals hidden by the approximate frequency noise. In this topic, we propose a new method of stochastic resonance for recovering the nanosecond noise-hidden signal in an optical nonlinear system and experimentally demonstrate this method with a high cross-correlation gain.

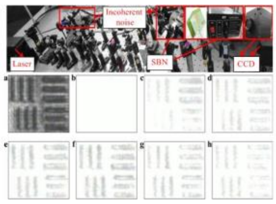


**Figure 1.** Experimental setup and observations of image reconstructions via SR

A typical experimental setup is shown in Fig.1. A nanosecond pulse laser with the wavelength of 532 nm is split into two beams, the pulse signal is purely coherent and an image of a resolution chart, the pulse noise is spatially incoherent with random phase fluctuations and generated by ground glass diffusers. The pulse signal and pulse noise are collinearly injected into the SBN crystal with applied voltage across optical axis. After the nonlinear coupling, light exiting the crystal is recorded by a charge-coupled device camera.

As shown in Fig.1, it is found that the pulse noise-hidden images grow and become visible when the energy transfers to signal from noise background. The combined interaction of strong random noise, weak signal and nonlinear system allows the visibility improvement of overwhelmed images. The output properties of images are mainly determined by the repetition frequency, the pulse width, the input signal-to-noise intensity ratio, the applied voltage across the medium, and the correlation length of noise background. Meanwhile, we also experimentally verify that the pulse signal images can be reconstructed from a continuous background noise. It does no longer need the time synchronization and allows a large repetition frequency range.

In conclusion, we have demonstrated a practical technology for pulse noise-hidden image reconstruction via stochastic resonance. This work provides a flexible and compatible approach for detecting pulse noise-hidden images in various imaging fields such as remote sensing, medical imaging, security monitoring, and so on.

**References**

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