Spectral Signal and Noise from Time-Varying Sources

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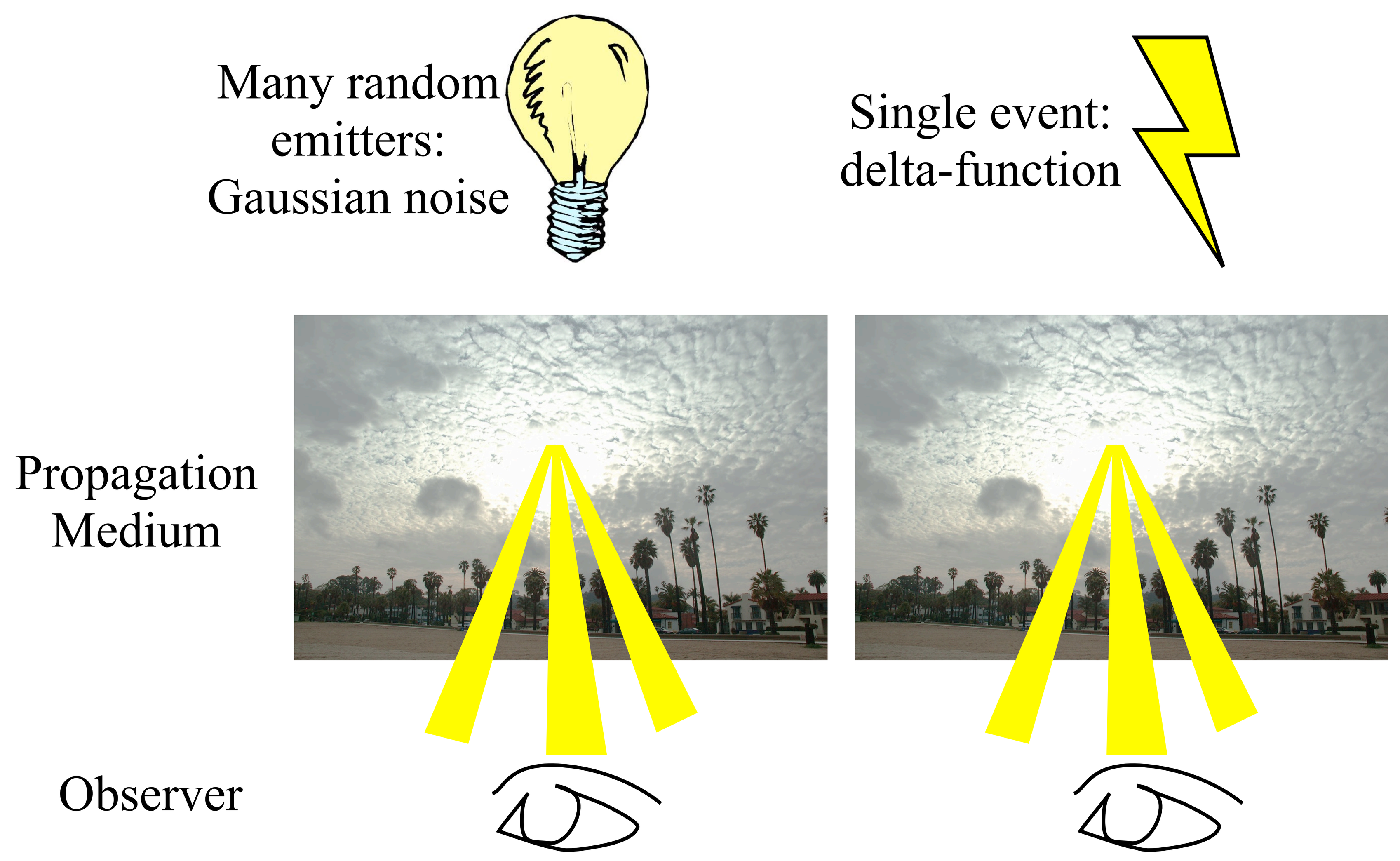
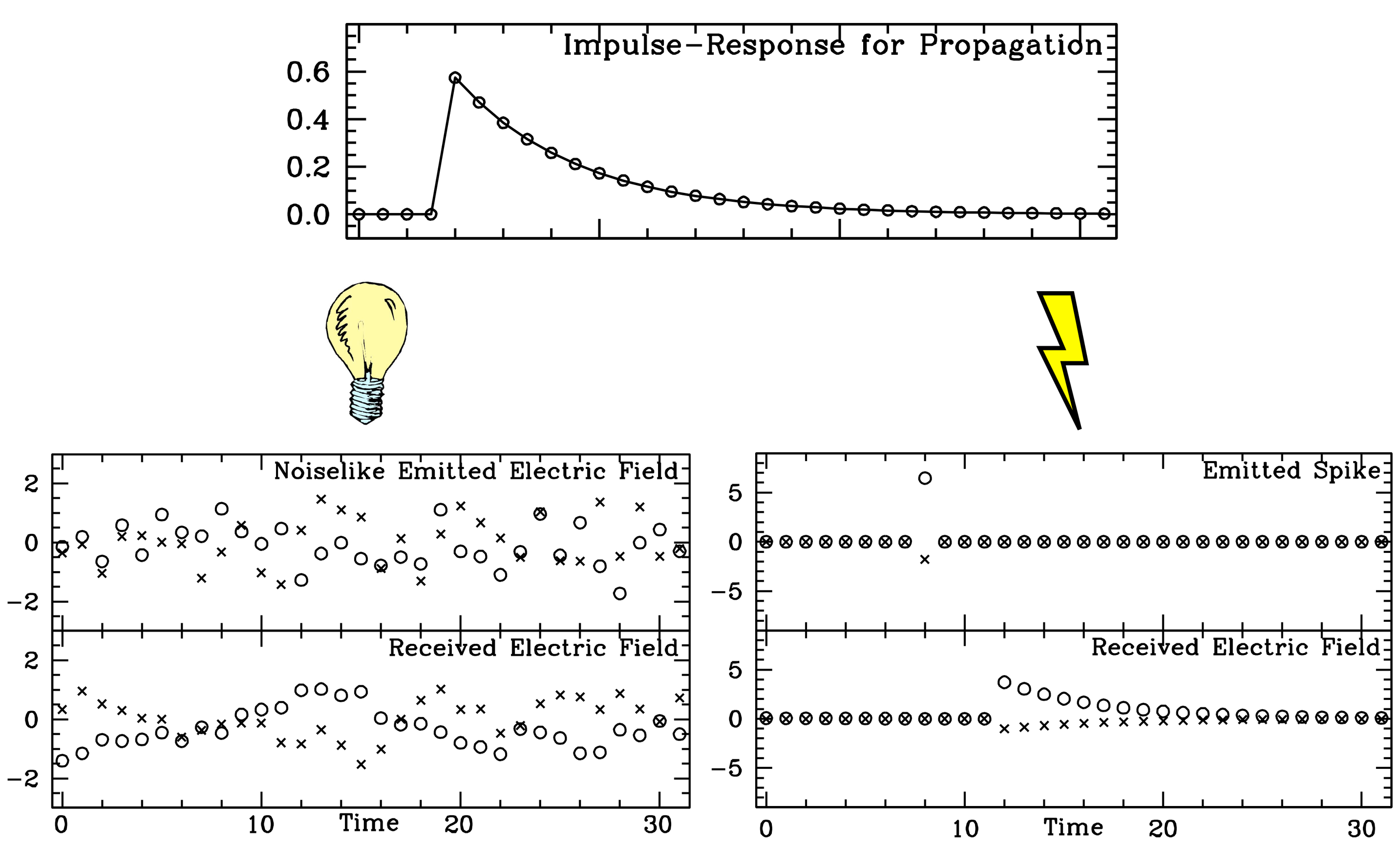
Abstract

Pulsars, like other astrophysical sources, emit noise. For pulsars, that noise is strongly modulated, on timescales of many seconds to nanoseconds or shorter. Scattering and dispersion in the interstellar medium convolve that the emitted electric field with a “propagation kernel” or “impulse-response function”. Convolution smears out the time-variations. We show that despite the convolution, signatures of intermittent emission persist, in the noise of the autocorrelation function of the electric field. This may be useful for detecting short-term variations of other astrophysical sources.

2 Sources

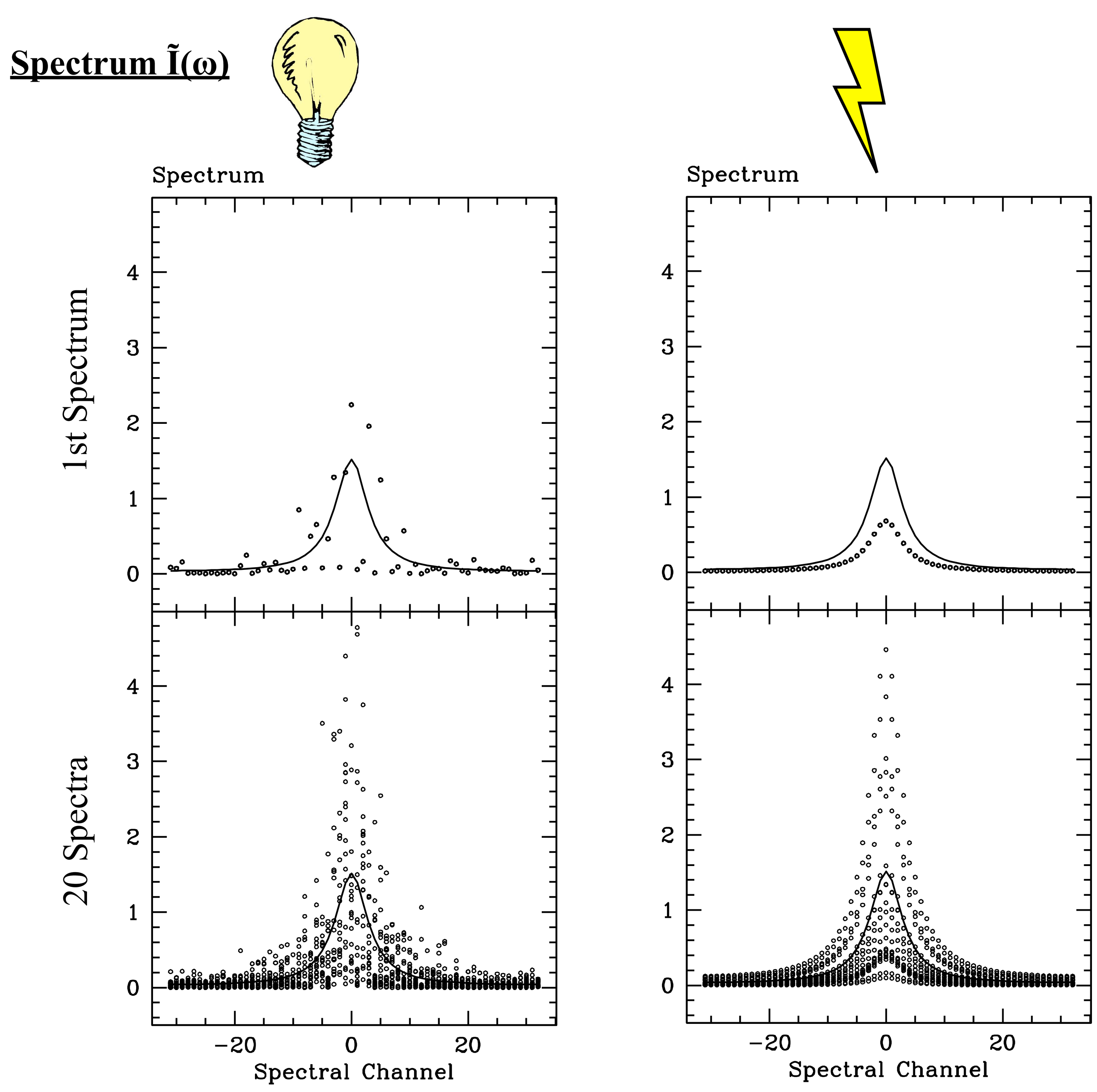


Emitted and Received Electric Fields



Form Spectra

We can form spectra by Fourier transforming these time series to the frequency domain, then taking the square modulus.

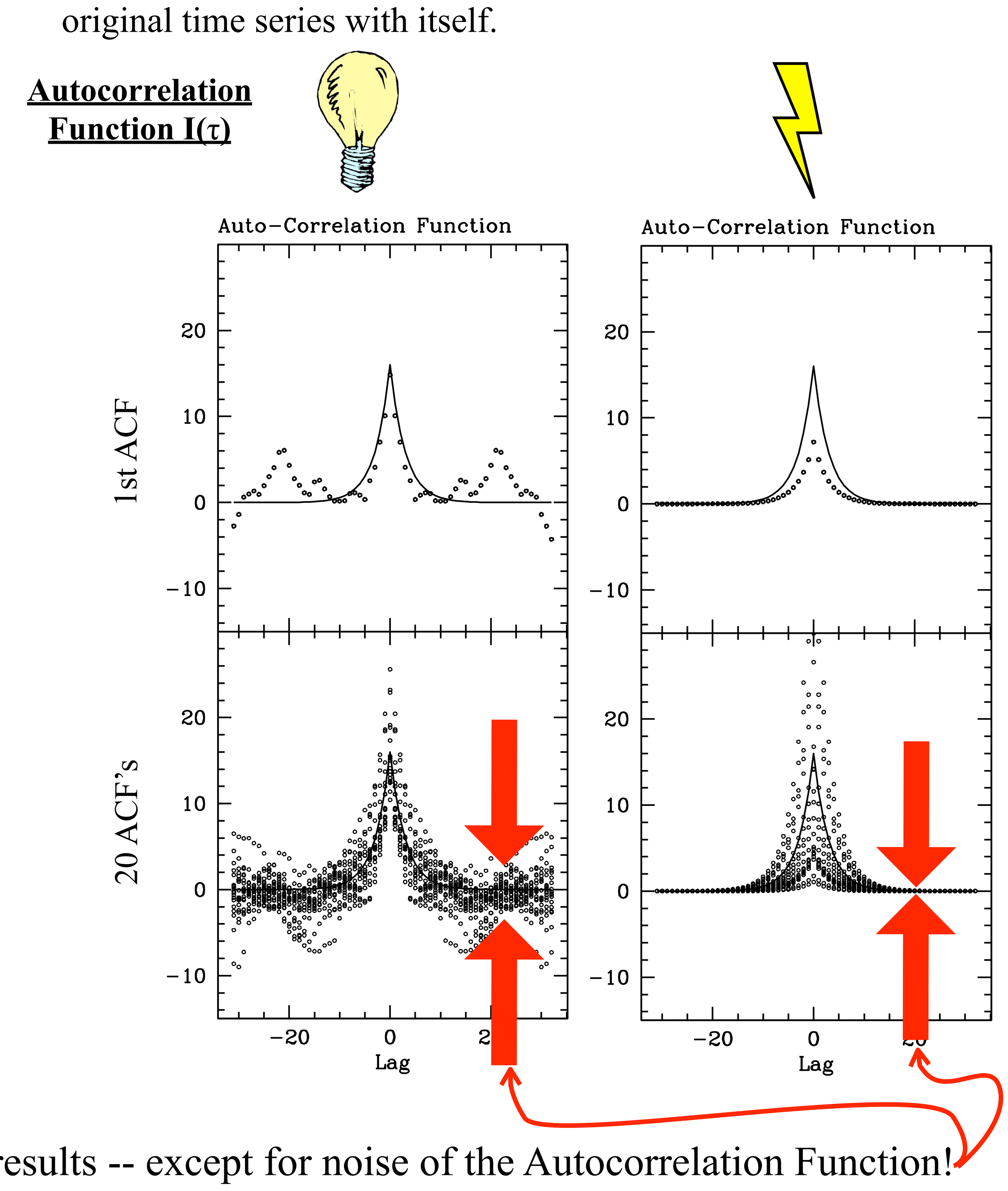


Form Autocorrelation Functions

The autocorrelation function is the Fourier transform of the spectrum.

It’s a function of time lag, τ.

You can also form the autocorrelation function by correlating the original time series with itself.



⇒ Gaussian Noise and Delta-Function produce identical results -- except for noise of the Autocorrelation Function! Noise is evenly distributed for Gaussian noise, but concentrated near zero lag for the ACF.

Things to Think About

- Average spectrum and autocorrelation function, and noise on the spectrum, depend only on propagation.
- The noise* in the autocorrelation function depends on whether the source is intermittent (as well as propagation).
- We see the effect for pulsars. Can this technique detect intermittent emission from other sources? Masers? AGN?

*Background noise (from sky or instrument) doesn’t care whether the source is intermittent. Only noise from the source cares.

To appear in ApJ. See also: www.arxiv.org/astro-ph/0216220 and 0216226 or www.physics.ucsb.edu/~cgwinn/noise/