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# RELATIVISTIC KLT FOR SPACE COMMUNICATIONS

**Abstract**

SETI, the Search for Extra-Terrestrial (ET) Intelligence, is today mainly the search for ET radio signals. At least two types of ET signals may possibly exist:

1. Stationary and narrow-band intentional signals suitable to be detected by the Fast Fourier Transform (FFT): this is the bulk of "Classical SETI" as it was conducted worldwide since 1960
2. Non-stationary (transient) leakage signals over wide bands that cannot be detected by the FFT. This is "terra incognita" in SETI and must be explored by both new detection algorithms and the use of innovative computational infrastructures, for instance GPUs (Graphic Processing Units) to cope with the huge amount of computations

The KLT (Karhunen-Loève Transform) is defined as follows: suppose that whatever arrives inside your radio telescope is noise, plus a signal buried inside:

1. Numerically compute the autocorrelation of this input noise.
2. Perform a principal axes transformation of this $NxN$ autocorrelation matrix, terribly demanding in terms of computational burden since it goes like $N^2$. The new matrix is diagonal and you then SORT the eigenvalues in a decreasing order of magnitude. Those eigenvalues correspond to the FFT frequencies already sorted in decreasing order of importance.
3. There is a one-to-one correspondence between eigenvalues and eigenvectors, so you may use the most important eigenvectors to reconstruct the signal approximately: good for transients.

As such, the KLT turns out to be superior to the classical FFT in several regards:

1. The KLT can filter signals out of noise of any kind over both wide and narrow bands. That is in sharp contrast to the FFT that rigorously applies to narrow-band signals embedded in white noise only.
2. The KLT can detect signals embedded in noise to unbelievably small values of the Signal-to-Noise Ratio (SNR), like $10^{-3}$ or so: it all depends on how much computational power you have.
3. So far we assumed that the source of the feeble signals is (nearly) still in the sky, like a stellar system where you only have to account for the Doppler shifts of the orbiting planets.
4. As early as 1994 did one of the authors, Claudio Maccone, take the pleasure of extending the KLT so as to encompass special relativity. This means that the relativistic KLT would be able to detect signals coming not only from still sources, but also from spaceships moving relativistic speed.