RELATIVISTIC KLT TO LINK UP WITH VERY FAST RADIO SOURCES LIKE QUASARS & PROBES.
C. Maccone, Co-Vice Chair, SETI Permanant Study Group, International Academy of Astronautics
Mailing address: Via Martorelli 43 – 10155 Torino (TO) – Italy - E-mail: elmaccon@libero.it

Abstract: The KLT (Karhunen-Loève Transform) has long ago been suggested as the optimal tool for filtering weak signals out of the background noise in SETI and radio astronomy (see Chapter 10 in ref. [1]). The higher computational burden requested by the KLT (order of N^3) with respect to the classical FFT (order of N*log(N)), however, has prevented so far the replacement of the FFT by the KLT in SETI and Radio Astronomy. Yet the displacement of the good old FFT by the KLT is just a matter of time and increased computer power: the KLT, in fact, can recover signals in a much lower SNR than the FFT, and also over broadbands and for non-stationary input stochastic processes, like transient phenomena.

In this paper we present the relativistic KLT, i.e. the KLT enabling us to link up with very fast-moving radio sources like quasars (i.e. relativistic cosmological objects) and/or spaceships moving at a relativistic speed (whether future human probes or current advanced alien probes moving in the Galaxy).

The mathematical theory of the relativistic KLT stems out of two facts:
1) The well-known Einstein’s Special Theory of Relativity and
2) The far less well-known Theory of The TIME-RESCALED GAUSSIAN PROCESSES, i.e. Brownian Motion for which the time does NOT elapse uniformly but, rather, dilates and stretches in a highly non-linear fashion.

About 25 years ago this author was able to analytically solve the integral equation yielding the Karhunen-Loève eigenfunctions of all time-rescaled Gaussian processes. He thus paved the way to the Relativistic KLT Theory described in this paper. However, he published his results in a purely mathematical fashion and in a little-known Italian mathematical journal (ref. [2]), and so they went largely unnoticed by the international scientific community.

But now the situation has changed:
1) In cosmology, quasars ARE relativistic objects, and so it might be interesting to replace our relativistic KLT to the good old FFT in the signal processing for Quasars and see what comes out of this mathematical change.
2) In SETI, the relativistic KLT might enable us to pick up signals from alien spaceships moving “fast” (i.e. at relativistic speeds) in the Galaxy, even if these signals are very weak. This is because the KLT works for SNRs much lower than the FFT and over broad bands.
3) Finally, one cannot rule out even the possibility of an alien spaceship approaching the Earth, as shown in the movie “Independence Day”. In this case, our relativistic KLT might enable us to detect the approaching spaceship by noticing its “sudden slowing-down” from relativistic speeds to virtually zero speed (see ref. [1], pages 199-200 for the relevant mathematics).

In conclusion, in this paper we explicitly give the equations for the KLT of getting signals on Earth coming from three differently moving relativistic radio sources:
1) QUASARS that move away from us at constant speeds. The KLT eigenfunctions are then sines just as in the KLT of standard Brownian motion, but the KLT eigenvalues change considerably.
2) HUMAN SPACESHIPS getting away from Earth at a constant acceleration with respect to the spacecraft itself. This is called “hyperbolic motion” by particle physicists, and we prove that the KLT eigenfunctions for this case are Bessel functions of the first kind and of zero order, suitably rescaled in time.
3) ALIEN SPACESHIPS approaching the Earth in their “deceleration phase”, and we prove that the KLT eigenfunctions are again Bessel functions of the first kind, but radically different from the previous case.

Our final statement is simple: “Star Trek”-like Relativistic Telecommunications, based on the KLT, are becoming a physical reality!

Keywords: Special relativity, Telecommunications, KLT, Relativistic Interstellar Flight, Bessel Functions of the First Kind.

References: