A GALACTIC POSITIONING SYSTEM

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ABSTRACT. Relativistic Positioning Systems are the best realizations of coordinate systems conceived up to now. We propose to use the signals of millisecond pulsars as a relativistic positioning system valid in and beyond our Solar System. The analogue of a GPS receiver is here a radio telescope, so that such a positioning system is heavy to use, but its interest is strong. Its study constitutes a simplified version of the relativistic positioning system recently proposed as primary reference system for the Earth [1]. A simple qualitative analysis of this last system and its relation to the usual, conventional reference frames may be made, allowing to better understand this new class of coordinate systems.

1. POSITIONING SYSTEMS

A coordinate system is a mathematical object. A detailed protocol for its physical construction in the space-time is called a *location system.* A coordinate system may always be defined by its coordinate (hyper-)surfaces. Consequently, the physical objects needed to define a location system are *nothing but* those physical fields able to describe parameterized (hyper-)surfaces.

The most interesting class of location systems are the *positioning systems*, which allow every event to know immediately its own coordinates. Four sources in arbitrary motion in space-time, broadcasting parameterized light signals, constitute the ingredients for such positioning systems, these signals drawing cones centered on the world line of the sources, i.e., parameterized families of (hyper-)surfaces. The coordinates of a space-time event are then, by definition, the values of the parameters (t^1, t^2, t^3, t^4) of the four signals, as recorded by a receiver at the event.

2. THE GALACTIC POSITIONING SYSTEM

We propose to use millisecond pulsar pulses as the light signals for a positioning system valid for the Solar System and its neighbours. The pulses being sequenced, they need only to be parameterized, that is, enumerated with respect to an origin.

Because of the anomalies in shape and arrival time within the average pulse period [2], it is possible to broadcast a 'signature' of signals allowing any user to identify the origin and, consequently, to find its proper coordinates.

A Galactic frame has already proposed. Its definition, as well as a first mathematical description, may be found in http://coll.cc . With present-day technology, this locates any space-time event with an accuracy of the order of 4 ns, i.e., of the order of one meter. This is not an extremely precise coordinate system, but it is extremely stable and has a great domain of validity.

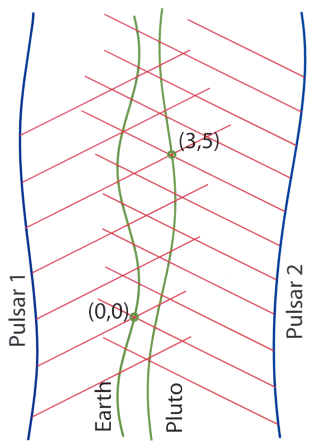

Figure 1: The anomalies in shape and arrival time of pulsar's pulses allow to identify, parameterize and broadcast the pulse chosen as origin. Then, any observer (event) in the Solar System may know its own coordinates.

A first point of interest in the analysis of the Galactic positioning system based on pulsars, is its relatively simple mathematical structure, as compared with its Earth analogue based on a constellation of satellites.

This advantage not only allows *i)* to make easy many calculations, but also *ii)* to give the first explicit example of Minkowskian relativistic positioning systems, *iii)* to interpret it as the instantaneous asymptotic limit of the relativistic GNSS and *iv)* to take it as the order zero in the gravitational field of more realistic models.

The possibility for the Earth to share a common immediate and relativistic coordinate system with other planets and satellites would improve the precision to which we know their position and trajectories. Should we, one day, be able to equip space-crafts with receivers of pulsar signals (in fact, miniature radio telescopes), they could continuously send their space-time position to us. This would help, for instance, in better understanding the vicinity of our Solar System and, in particular, Pioneer 10/11, Galileo and Ulysses acceleration anomalies [3].

We are grateful to François Biraud for helping in the selection of the four pulsars.

3. REFERENCES

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