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This program focuses on observations of three two approaches of Jupiter and Saturn to compact radio sources in 2008-2009. The close planetary approaches allow us testing the theory of General Relativity (GR) with unprecedented accuracy by making use of group delays from geodetic VLBI data. The GR parameter γ in the Jovian and Saturnian gravitational field as well as a tangential (retarded) deflection will be estimated.
Ephemeris calculations yield:

1. Approach of Jupiter to the quasar 1922-224 by 1'.4 on 19 November, 2008.
2. Approach of Saturn to the quasar 1125+062 by 1'.3 on 11 February, 2009.

I request two special sessions during 2008-2009 year for this program. The data should be restricted to PI for six month period (counted from the day of correlation) to provide time frame for data analysis and interpretation of the results.

Justification

Light propagation in gravitational field of a static massive body results in the deflection and time delay of light in accordance with Einstein's general theory of relativity. The time delay due to travelling in a static gravitational field (Shapiro, 1964) was confirmed is a series of experiments done in the field of Sun. However, more advanced theory of light deflection by moving bodies (Kopeikin and Schäfer, 1999) reveals a number of high-order post-Newtonian corrections to the classic Shapiro delay. The most intriguing prediction of this theory is that the relativistic time delay of light depends on the retarded positions of the moving body due to finite speed of gravity (Kopeikin, 2001, 2003).

Relativistic time delay of light in the gravitational field of Jupiter has been measured in VLBI experiment on 8 September, 2002 when Jupiter passed within 3'.7 of the quasar 0839+187 (Fomalont and Kopeikin, 2003; Petrov, 2004). Fomalont and Kopeikin (2003) estimated the gravity retardation effect (presumably associated with the finite speed of gravity) with accuracy of 20% using VLBA phase-referencing observations. Petrov (2004) used the geodetic VLBI technique but came to the conclusion that the group delays were not accurate enough to measure the retardation effect as the formal error was comparable with its magnitude.

Three approaches in 2008-2009 are more favourable for detection of the retardation effect because the planets will pass closer to the quasars than in 2002 (Table 1). The approach of Jupiter in November, 2008 at the angular distance of 1'.4 to the quasar 1922-224 is the closest one since 1984. The closer approaches will take place only in 2015 (for Saturn) and 2017 (for Jupiter) with rather bad observational conditions (almost beyond the Sun). Observing the close pass at the angular distance θ we can measure the bending of light from the radio sources due to the Einstein deflection (proportional to the θ^{-1} angular distance). The gravity retardation effect is proportional to θ^{-2}. The maximum magnitude of the retardation effect in the light deflection will be up to seven times larger than in 2002, so there is a rare opportunity of measuring it with sufficient accuracy from group delays.

However, the estimate of this effect is proportional to the mean squared angular distance around the minimum angular approach if observations of the source are evenly distributed during the 24 hour session (Fig 1 and Fig 2). The corresponding mean squared retardation effect is evaluated in the last line of Table 1. The formal error of the retardation effect is supposed to be 35 μas (based on the results from the experiment in 2002, (Petrov, 2004)). For shorter period of observational time the mean squared retardation effect will increase. The estimates for 12-hour VLBI session are shown in Table 2. It means that more advanced schedule to be developed. For instance, the schedule with unevenly distributed scans of the source during 24 hour session (more scans near the closest approach and less scans otherwise) will provide sufficient accuracy to indicate the retardation effect from group delay measurements.

Assuming the formal error of the daily estimate for the retardation effect will be better in 2002 and reach ~20 μas it is possible to make assessment of the expected accuracy for the events in 2008 and 2009. The GR parameter γ for the Shapiro delay in the Jovian gravitational field will be measured with accuracy of 0.7%, and in the Saturnian gravitational field with accuracy of 2%.

If the measured retardation effect is in a range from 158 to 350 μas the estimate will be measured with accuracy from 6% to 12% (for the Jupiter approach in 2008); and from 35% to 50% (for the Saturn approach in 2009).

In 2008 this event will occur in the southern hemisphere, therefore a good selection of the southern hemisphere VLBI sites is required to undertake a successful experiment. The best geographic regions for this event observation are the North and South America, and Pacific. For this reason, it would be reasonable to include Hobart26, Parkes, Hartrao, Fortaleza, Tigoconc, and, probably, DSS45 to ensure receiving a good-quality data. I am going to apply for 24-hour session in Parkes (deadline is 15 of June, 2008) and request for several hours of observing time on DSS45 for the dates on 18-19, November 2008. As to the northern hemisphere it would be helpful to add to the network Westford, Tsukub32 and Kokee. Special schedule should be prepared to make as many scans of the encountered quasar as possible along with sufficient number of scans for making good link with other radio sources. The data rate 1 Gbps is essential.

For the Saturn's approach in 2009 there is no so strong requirement on the VLBI network configuration. Usual R&D network enforced by 2 or 3 dishes from the southern hemisphere can be used for these experiments. Eventually, data from two sessions can be adjusted in one combined solution to get better statistics.

References:

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Year	2002	November, 2008	February, 2009
Planet	Jupiter	Jupiter	Saturn
Quasar	0839+187	1922-224	1125+062
Minimum angular approach	3’.7	1’.4	1’.3
Mean squared angular distance for 24-hour session	25’.5	12’.0	3’.0
Maximum static gravitational bending (Einstein deflection)	1190 μas	3145 μas	1130 μas
Maximum retardation effect	51 μas	350 μas	70 μas
Mean squared retardation effect for 24-hour session	28 μas	58 μas	39 μas

Table 1: Close planetary approaches to quasars and the estimates of GR parameters for 24-hour session

Year	2002	November, 2008	February, 2009
Mean squared angular distance for 12-hour session	16’.8	4’.4	2’.1
Mean squared retardation effect for 12-hour session	43 μas	158 μas	56 μas

Table 2: Estimates of the retardation effect for 12-hour session