MERCURY SPIN DYNAMICS FROM RADAR SPECKLE DISPLACEMENT. Igor V. Holin (Kravchenko str. 12-244 Moscow 119331 Russia, ivholin@mail.ru).

Introduction: Spin-vectors $\mathbf{\Omega}(t)$ of planets relate to their interiors and evolution. High precision estimates of the instantaneous spin rate $\Omega(t)$ and spin-vector orientation $\mathbf{\Omega}(t)/\Omega(t)$ of a rough rigid rotating planetary surface can be obtained from moving scattered radar speckles ([1],[2] and references there in). The theoretical measurement accuracy in $\mathbf{\Omega}(t)$ for Earth-based radar was discussed with respect to the Holin (1988, 1992) technique (HT) in case of identical echoes corrupted by electronic noise [3]. Now I take into account the effects of partial coherence of input signals.

Cramer-Rao lower bound (CRLB): Early analysis of HT accuracy in $\Omega(t)$ [3] is consistent with the experimentally confirmed CRLB for time delay estimation of noisy identical signals [4]. Taking into account that in HT experiments the radar signals are not identical even in absence of electronic noise and this non-identity can be treated as the presence of another independent noise, we come to the corresponding CRLB for noisy partially coherent signals. Below these CRLBs (relative standard deviations σ, $\times 10^{-5}$) in $\Omega(t)$ for electronic (e) and decorrelation (d) noises are calculated for some of the appropriate baselines and the 70 m, 450 KW, 3.5 cm CW radar at Goldstone in South California (USA).

Baseline	e	d
Goldstone – Green Bank	0.5	2
Mauna Kea – St. Croix	0.8	1.5
Mauna Kea – VLA	0.2	0.4
Green Bank - Mauna Kea	0.8	2
Brewster – Hancock	1.5	3
Green Bank - Owens Valley	1	3
Owens Valley - Hancock	1.5	3
Green Bank – VLA	0.2	0.6
St. Croix – Kitt Peak	1	2.5
St. Croix – Fort Davis	1.1	2.7
St Croix – VLA	0.2	0.5
Mauna Kea – Fort Davis	1	2.5

Along with the 70 m Goldstone and 100 m Green Bank dishes, I use the 25 m VLBA and VLA antennas. Like VLBA, VLA works here as a collection of separate dishes. As compared to e-noise, d-noise causes substantial change for the worse in accuracy especially for large antennas, so with the same level of e-noise the interferometer 25 m Mauna Kea – 25 m St. Croix can be better than 70 m Goldstone – 100 m Green Bank due to a longer baseline. Joint use of the existing radio telescopes leads to the one-day $\sigma \sim 3\times10^{-6}$, one-conjunction σ (~ 20 days) better than 10^{-6}, and one-decade σ approaching 10^{-7}.

Averaging in time and frequency: Radar systems can use multifrequency transmission. E.g., the total ~ 10 MW transmitting power can be distributed over 10^3 monochromatic signals spaced in frequency by ~ 10 KHz to ensure the independence of speckle patterns. The d-noise calculations for a 100 m transmitting antenna show that with the 100 m receiving dishes in a two-element interferometer, such as Goldstone – Green Bank, each monochromatic signal during the observation time ~ 15 seconds gives $\sigma \sim 2\times10^{-5}$, so 10^3 signals will lead to $\sigma \sim 10^{-6}$ within a single experiment, which is already better than the above mentioned joint use of the existing facilities. In case of regular variations in $\Omega(t)$, the one-decade σ can approach 3×10^{-8}.

Averaging in time and space: The above limits can also be met with the 25 m antennas and the existing 450 KW Goldstone CW radar. Imagine, there are two arrays, each consisting of 30 dishes. The arrays are spaced by several thousands kms. Each long baseline pair of dishes gives $\sigma \sim 2\times10^{-5}$, so 30×30=900 pairs will give the one-day $\sigma \sim 10^{-6}$ and one-decade σ approaching 3×10^{-8}.

Averaging in time, space, and frequency: For both the 100 m, 10 MW, 20-frequencies transmitter and two 30-dishes arrays of 25 m antennas, each pair of dishes gives $\sigma \sim 5\times10^{-6}$. All pairs give the one-day $\sigma \sim 2\times10^{-7}$ and one-decade $\sigma \sim 7\times10^{-9}$.

Conclusion: Using averaging in time, space, and frequency, Mercury's instantaneous spin rate $\Omega(t)$ and regular spin rate variations $\omega(t) = \Omega(t) - \Omega_0$ (Ω_0 is the mean spin rate) of order $\omega(t)/\Omega_0 \sim 10^{-4}$ and smaller can be measured to a very high precision by Earth-based radar systems for partially coherent noisy echoes as well. Note that the direct HT measurements of $\mathbf{\Omega}(t)$ components need no *a priori* assumptions about Mercury's unknown properties. In such a way truthful, objective, and independent constraints on the interior and evolution of Mercury can be obtained.

References: [1] Holin I.V. (2010) *Icarus, 207,* 545-548. [2] Holin I.V. (2002) *Solar Syst. Res., 36,* 206-213. [3] Holin I.V. (1992) *Radiophys. Quant. Elec., 35,* 284-287. [4] Carter G.C. (1987) *Proc. IEEE, 75,* 236-255.