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Improved computation of gravity-dependent signal path variation models for Cassegrainian VLBI telescopes with tapered illumination functions

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Gravitational deformations of very long baseline interferometry (VLBI) telescopes structure can bias the observed geometric delay to a non negligible extent with considerable effects on the height estimate of the VLBI reference point. Therefore, the action of gravity has to be modelled and quantified adopting elevation-dependent signal path variation (SPV) models. These latter are strictly antenna-related and are expressed as a linear combination of three gravity-dependent deformation patterns of the antenna structure:

$$\Delta L(e) = \alpha_F \Delta F(e) + \alpha_V \Delta V(e) + \alpha_R \Delta R(e)$$

$(\Delta F, \Delta V, \Delta R)$ being the variations of focal length of the paraboloid, the vertex and the receiver displacements. α_F, α_V and α_R are linear coefficients whose values are related to the geometry of the VLBI telescope, the optical properties of the primary and secondary reflectors and the feed horn illumination function (IF).

In this contribution we set the rules for an optimal definition of precise SPV models, revising and highlighting the deficiencies in the calculations adopted in previous studies and improving the computational approach. Earlier studies usually determined the values of the α coefficients assuming a uniform illumination of the reflectors. We prove this hypothesis to be over-simplistic by comparing results derived adopting the uniform IF and tapered IFs (e.g. Gaussian and binomial). Computations are developed for AZ-EL mount, 32 m Cassegrain Medicina and Noto (Italy) VLBI telescopes: assuming a Gaussian IF, the path variation over the elevation range $[0, 90]$ deg is 10.1 mm and 7.2 mm, respectively. With uniform IF the path variation for Medicina is 17.6 mm and 12.7 mm for Noto. Elevation-dependent SPV models are rigorously developed both for primary and secondary focus observing configuration. According to our findings, a revised SPV model is released for Medicina antenna and a model for Noto telescope is presented here for the first time. Currently, no other VLBI telescopes possess a model capable of correcting gravity-induced observation biases.