

Towards Planet Nine Identification via a General Residual-Based Detection Method

Abstract. This work develops an abstract, domain-independent framework for detecting the presence of an unobserved body from its effect on the mutual relationships among already-known bodies, motivated by the search for a hypothesized ninth planet inferred from anomalies in trans-Neptunian object (TNO) orbits. The starting idea is that a new entity, even one that does not interact directly with any single known object, can only be inferred through a deviation in the known system’s own internal consistency. For a set of known objects A, B, C , we define pairwise observable quantities $AB(t), AC(t), BC(t)$, and separate each into an *expected* value, governed only by the known objects’ mutual behavior, and an *observed* value, reflecting the system as it actually is. The residual $\varepsilon_{AB} = AB_{\text{observed}} - AB_{\text{expected}}$ (and analogously for AC, BC) vanishes if and only if no new influence is present. Because a single unseen body would affect all three pairwise relations simultaneously, we hypothesize a shared unknown u underlying the three residuals, $\varepsilon_{AB} = f_{AB}(u), \varepsilon_{AC} = f_{AC}(u), \varepsilon_{BC} = f_{BC}(u)$, and recover candidate values of u by inversion, $u = f_{AB}^{-1}(\varepsilon_{AB}) = f_{AC}^{-1}(\varepsilon_{AC}) = f_{BC}^{-1}(\varepsilon_{BC})$. Agreement among the three independently recovered values constitutes the mathematical signature of a genuine shared cause, while disagreement indicates either no such cause or an incorrect assumed relation. This construction mirrors the historical discovery of Neptune from residuals in Uranus’s orbit and the current observational strategy for Planet Nine, in which clustering in the orbital elements of multiple independent TNOs is used to infer a common perturber. The methodology developed to this point remains deliberately abstract: the forms of $AB_{\text{expected}}, AB_{\text{observed}}$, and f_{AB}, f_{AC}, f_{BC} are left unspecified, so that the framework captures the general logical structure of presence-by-residual rather than any one physical instantiation, with a concrete gravitational realization identified as a natural, but separate, next step.