Neutron Star Kicks in Isolated and Binary Pulsars: Observational Constraints and Implications for Kick Mechanisms

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We study observational constraints on neutron star (NS) kicks for isolated pulsars and for NSs in binary systems. We are particularly interested in the evidence of kick-spin alignment/misalignment and its dependence on the NS initial spin period. For several young pulsars, X-ray observations of compact nebulae showed that pulsar proper motion is aligned with the spin direction as defined by the symmetry axis of the nebula. We also critically examine the measurements of the proper motion and the projected spin axis from a large sample of pulsars with well-calibrated polarization data. We find that among the two dozen pulsars for which reliable measurements are available, there is a significant correlation between the spin axis and the proper motion. For various NS binaries, including double NS systems, binaries with massive main-sequence star companions and binaries with massive white-dwarf companions, we obtain constraints on the kick magnitudes and directions from the observed orbital characteristics of the system. We find that the kick velocity is misaligned with the NS spin axis in a number of systems, and the NS spin period (when available) in these systems is generally longer than several hundreds milliseconds. These constraints, together with the spin-kick alignment observed in many isolated pulsars, suggest that the kick timescale is hundred of milliseconds to 1 s, so that spin-kick alignment or misalignment can be obtained depending on the initial spin period of the NS. We discuss the implication of our result for various NS kick mechanisms.