W29a Jet propagation and Cocoon Emission in Neutron Star Mergers and GW170817

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Here, we present a work that combines analytical modeling, numerical simulations, and numerical relativity, in order to solve jet and cocoon propagation in a given Binary Neutron Star (BNS) merger event. Our analytic solutions for jet head propagation show a good agreement with numerical simulations. We apply our model to GW170817 and successfully restrict the key parameters of the central engine, in particular we find that the engine isotropic luminosity should be in the range $\sim 3 \times 10^{49} - 2.5 \times 10^{52}$ erg s^{-1} erg/s. This implies that if observed on-axis, GRB 170817A would be as bright as any typical sGRB. Furthermore, we present an analytical modeling of the cocoon. As for GW170817, we show that in the first few hours after the merger, the bulk of the cocoon expands with an average velocity of $\sim 0.3c - 0.4c$, which is very comparable to the first photosphere velocity detections in GW170817. We estimate the cocoon in the prompt emission phase, as well as in typical late time engine activities, i.e. extended emission and plateau emission. Our findings show that the cocoon, in particular from late engine activities, is very bright in the first few hours, such as it shines over the early r-process powered macronova. We predict that future observation should be able to detect such cocoon component within the first few hours after the merger.