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ANALYSIS OF A SELF-CONSISTENT IMEX METHOD FOR TIGHTLY COUPLED NON-LINEAR SYSTEMS

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We introduce a mathematical analysis for our self-consistent Implicit/Explicit (IMEX) algorithm. This algorithm is designed to produce second order time convergent solutions to multi-physics and multiple time scale fluid problems. The algorithm is a combination of an explicit block that solves the non-stiff part and an implicit block that solves the stiff part of the problem. The explicit block is always solved inside the implicit block as part of the non-linear function evaluation making use of the Jacobian-Free Newton Krylov (JFNK) method. In this way, there is a continuous interaction between the implicit and explicit blocks meaning that the improved solutions (in terms of time accuracy) at each non-linear iteration are immediately felt by the explicit block and the improved explicit solutions are readily available to form the next set of non-linear residuals. This continuous interaction between the two algorithm blocks results in an implicitly balanced algorithm in that all the non-linearities due to coupling of different time terms are converged. In other words, we obtain a self-consistent IMEX method that eliminates the order reduction in time accuracy for certain type of problems that a classical IMEX method can suffer from. We note that the classic IMEX method splits the operators such a way that the implicit and explicit blocks are executed independent of each other, and this may lead to non-converged non-linearities therefore time inaccuracies for certain models. In this study, we provide a mathematical analysis (modified equation analysis) that examines and compares the time behavior of our self-consistent IMEX method versus the classic IMEX method. We also provide computational results to verify our analytical findings.