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HETEROGENEOUS ASYNCHRONOUS TIME INTEGRATORS BUILT FROM THE ENERGY METHOD FOR COUPLING NEWMARK AND α-SCHEMES

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Abstract. The time integration procedure selected in computational structural dynamics must possess at least the stability and accuracy properties required for the convergence to the exact solution. Other desired properties are the unconditional stability for linear dynamics, second-order of accuracy, high frequency dissipation capabilities, self-starting, no overshoot, one step method and no more than one set of implicit equations to be solved for each time step (single-step-single-solve format). In linear dynamics, the stability is classically assessed by a spectral study of the amplification matrix, whereas physical energy bounds are preferred in nonlinear dynamics. Popular a-schemes (HHT-α, WBZ-α, CH-α) are second-order accurate and provides numerical dissipation for spurious high frequencies due to the finite element discretization. To go beyond the standard approach based on the same time integration scheme (homogeneous time integration scheme) and the same time step for all the finite elements of the mesh (synchronous time integration), the purpose of this paper is to describe a general methodology for building Heterogeneous (different time integration schemes such as Newmark or a-schemes) Asynchronous (different time steps) Time Integrators (HATI) for computational dynamics. The key point for building the HATI methods is to cancel the interface pseudo-energy as introduced by Hughes in the so-called energy method employed for proving the stability of implicit-explicit algorithms in its pioneer works on heterogeneous time integrators. By canceling the pseudo-energy at the interface between subdomains and assuming a linear time variation of the Lagrange multipliers at the coarse time scale, the HATI method, called BCG-macro method, is derived. It can handle any dissipative α-schemes (HHT-α, WBZ-α, CH-α), while preserving the second-order of accuracy when adopting different time steps. In addition to the energy argument (cancelation of the interface pseudo-energy), the stability and order of accuracy is proved by the spectral study of the amplification matrix.