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A SMAC LIKE NOVEL EFFICIENT IMPLICIT MUSCL METHOD FOR ALL MACH NUMBER

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The formulation of a new all-speed compressible CFD scheme, which unifies a compressible CFD schemes of implicit MUSCL (Monotonic Upstream-Centered Scheme for Conservation Laws) [1] and an incompressible CFD scheme of SMAC (Simplified Marker and Cell) methods [2], SMUC (SMAC-inspired Mach Uniform Compressible scheme), is presented. SMUC scheme consists of a combination of an implicit scheme (GC-SMAC) and a Riemann flux (UD-SLAU) in the framework of the MUSCL-FVM. GC-SMAC can compute very low Mach number flows stably without adjustment of flow-field-dependent parameters such as Mc (Cutoff Mach Number), unlike the scheme based on application of time derivative pre-conditioning. [3] It is also shown that the procedure of SMAC method is theoretically derived from the operator factorization of minimum errors.

Numerical examples show improvements by this scheme, such as several times speed up to the convergence in low Mach number range. Its superiority in computational efficiency is clear to conventional schemes, including time derivative pre-conditioning method when M <0.1 or less, while efficiency equivalent to LU-SGS [4] etc. above subsonic speed being maintained. It is a great benefit that several times faster speed can be realized around M=0.1 (Fig.1), which is frequently used in low Mach number aerodynamic problems. In UD-SLAU, the pressure difference term in the mass flux term, which is the key to the low Mach number characteristic of the SLAU [5] type scheme, has been corrected in a manner highly compatible with GC-SMAC. The adjustment of Mc, which was necessary for the stabilization, was removed. Furthermore, numerical examples show that simultaneous computations of low M flows and sound waves are possible with the same parameters.

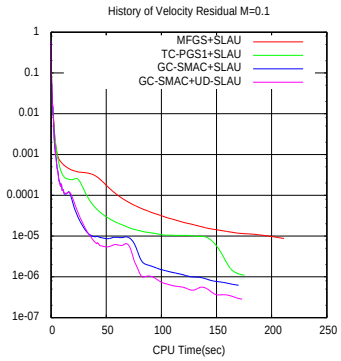

Fig.1 History of velocity residual of flow around NACA0012 at Mach=0.1.

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