Acceleration of vortex methods calculation using a special-purpose computer and FMM

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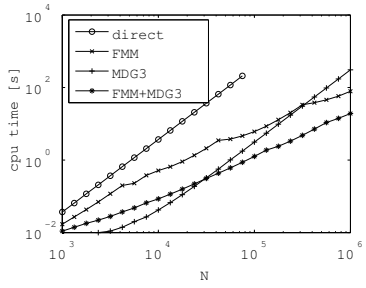
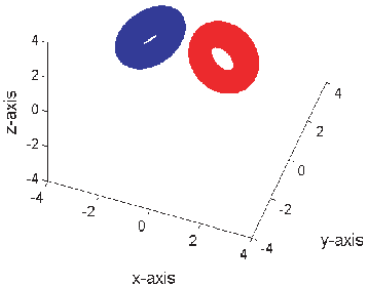
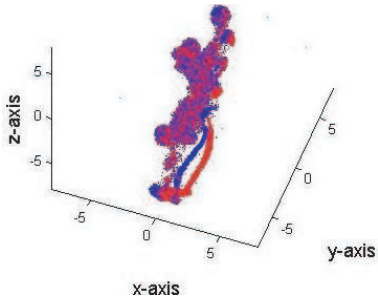
The present study discusses some numerical techniques on the simultaneous use of the Fast Multipole Method (FMM) and the special-purpose computer (MDGRAPE-3) to make the impractically expensive calculation feasible without the loss of numerical accuracy. Present author [1] has accelerated and modelled fast vortex method by using MDGRAPE-2 and the improvement in speed was 50 times at $N = 10^5$ when compared with the calculation of a conventional PC retained the numerical accuracy. The calculations are still impractically expensive for the number of particles $N \sim 10^5$ to onwards for the direct calculations. In the present calculations, the impingment of two identical vortex rings in various configurations has been studied. The preliminary calculation shows that the computation time has been reduced by a factor of 2000. Fig. (a) represents the acceleration achieved by the present scheme, without any acceleration technique is being used. It is clearly seen that the direct and MDGRAPE-3 calculations both have a scaling of $O(N^2)$, the use of the FMM brings them both down to $O(N)$.
Figs. (b) and (c) represent the position of inclined two vortex rings in two different times during collissions. In this calculations, the number of particles is 1.18×10^6 which is 2 to 15 times larger than the previous calculations done by the present author and the other researchers for the same flow field. The calculated results of global kinetic energy, enstrophy and energy spectra have good agreement compared with the others similar work.



(a) CPU Time



(b) Before Collissions (t=0)



(c) After Collissions (t=24)

Keywords : Vortex Method, Special-Purpose Computer, Fast Multipole Method

References

[1] T. K. Sheel, K. Yasuoka, S. Obi, Acceleration of Vortex Method Calculation using MDGRAPE-2: A special-purpose computer, Proc. ICVFM2005, pp. 137-142.