Sound generated by quadrupole near object

M.Hashiguchi[1], D. Mi[2]
1. Keisoku Engineering System., Co. Ltd., Chiyoda-ku, Tokyo, Japan
2. Keisoku Engineering System., Co. Ltd., Chiyoda-ku, Tokyo, Japan

INTRODUCTION: Aerodynamic sound is generated by unsteady fluid motion and enhanced when the flow becomes turbulent. For example, drone is loud because the ambient air is stirred by their propeller to get lift and movement and the air becomes turbulent. Reduction of aerodynamic noise is an important issue for environmental problem. It is well known that quadrupole in turbulent flow takes an essential role in generation of aerodynamic sound, but the mechanism has not been fully understood.

The present paper devotes numerical visualization on how acoustic field is formed when a quadrupole is set near an elliptical object.

COMPUTATIONAL METHODS: The acoustic field is treated based on the linearized Euler equations (LEE) and they were solved by the discontinuous Galerkin (DG) method, included in the acoustic module of COMSOL Multiphysics[1]. As shown in Fig.1, time stepping is performed to evolve acoustic field excited by a quadrupole near object.

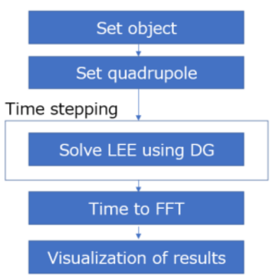

Figure 1. Sequence of computation.

RESULTS: At first, to verify the present method, we solved the same problem defined by Bailly and Juve[2], in which acoustic fields generated by sources of a dipole or a quadrupole with no objects were considered. It was found that the resulting acoustic fields shown in Fig.2 coincide well with those of Bailly and Juve[2]. Secondly, we extended the problem to include elliptical object. The background mean flow is assumed to be rest. A quadrupole was set at the location (x, y)=(-60, 0). Elliptical object was inclined at three angles of -15.0, 0.0 and 15.0 degrees to investigate the effect of relative position on the acoustic fields. Fig.3 displays acoustic pressure fields at 650 timesteps at different inclination angle of elliptical object. Microphone position is located at (x, y)=(0, 150) and the time histories of acoustic pressure at the location are shown in Fig.4. It seems that the present method can provide a useful tool to visualize the near field interaction between sound source and object.

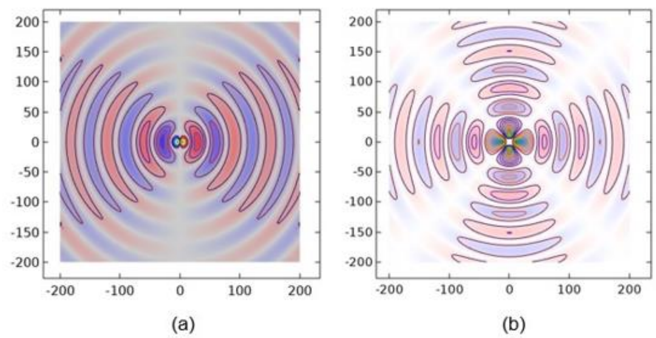

Figure 2. Acoustic fields generated by a source: (a) dipole; (b) quadrupole.

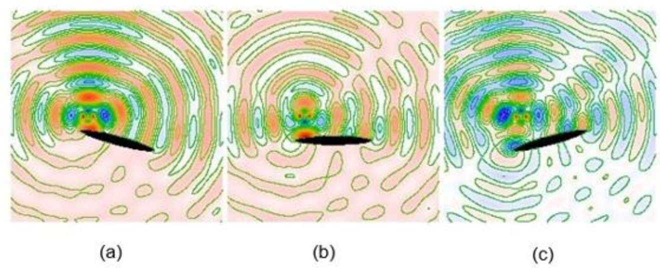

Figure 3. Acoustic fields generated by a quadrupole with an elliptical object positioned at: (a) -15 deg;(b) 0 deg;(c) 15 deg.

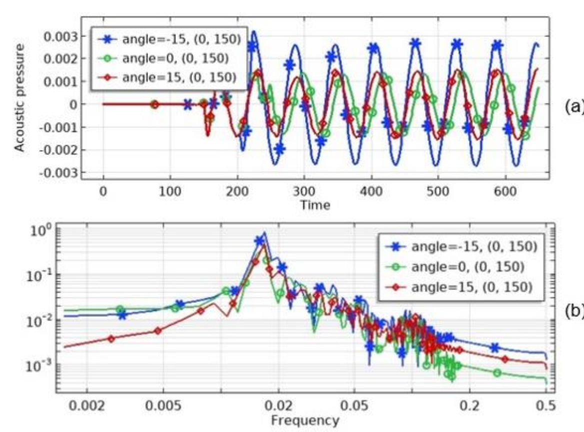

Figure 4. Pressure at microphone location: (a) Time histories; (b) Fourier spectrum.

CONCLUSIONS: Based on LEE, time evolution of acoustic fields excited by a quadrupole near object was examined. It was found that the attitude of object influences on the sound level of far field. In future work, study on effect of flow convection is planned.

REFERENCES:

1. https://www.comsol.jp/acoustics-module. (viewed at September 15, 2020)
2. Christophe Bailly and Daniel Juve, AIAA Journal, Vol.30, No.1, January 2000 (2000).