Numerical Simulation of Acoustic Properties of Porous Metals under High Sound Pressure Level Conditions

Bo Zhang, Xingbo Wang, Li Ni
School of Mechanical Engineering, Ningxia University, Yinchuan, China 750021

Introduction:

The aim of this work is to investigate the sound absorbing characteristics of porous metals at high sound pressure levels by using COMSOL Multiphysics® acoustic pressure interface and making the static flow resistivity be a variable.

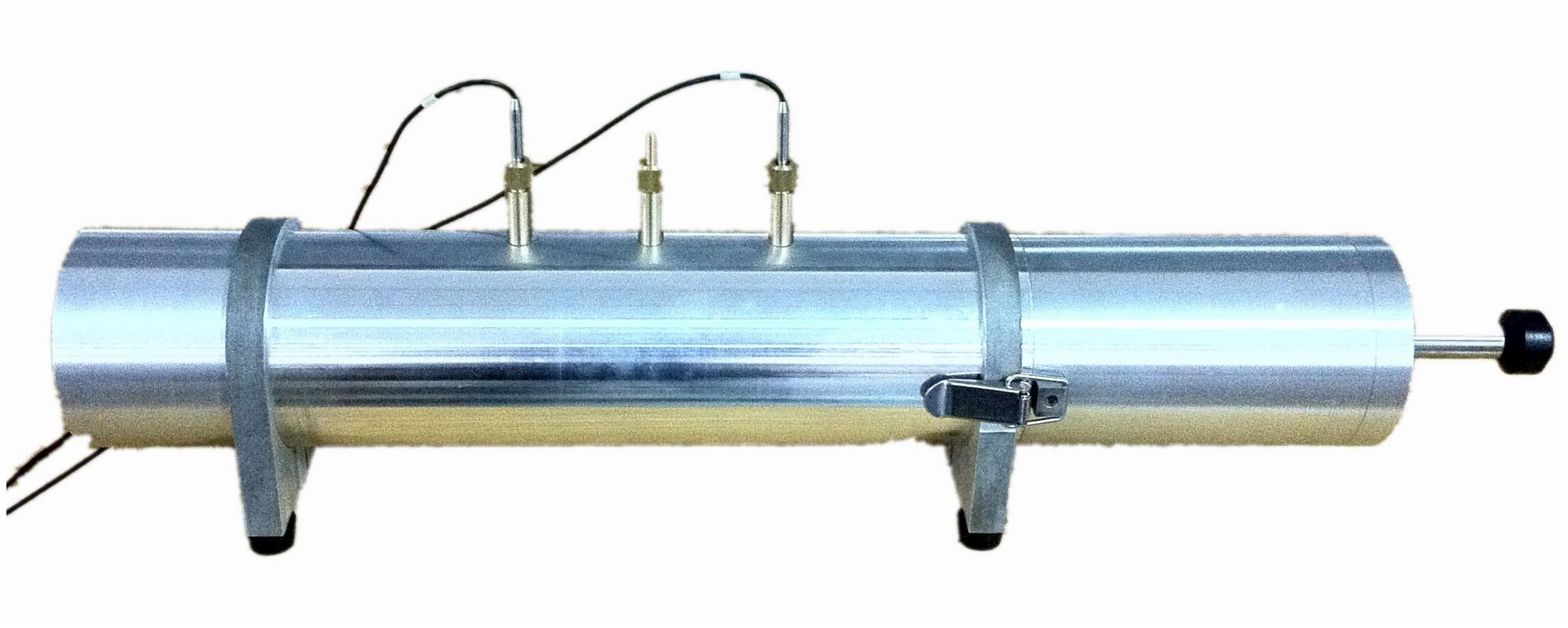

Figure 1 Impedance tube testing system

Computational method:

$$\nabla\cdot\frac{1}{\rho_c}(\nabla p_t-q_d)-\frac{k_{eq}^2}{\rho_c}=Q_m,\quad p_t=p+p_b$$

$$k_{eq}^2=(\frac{\omega}{c_c})^2-k_z^2,\rho_c=\frac{\rho_f c^2}{c_c^2}$$

Calculation model for the porous metal: J-C-A

$$\mathrm{K}=\frac{\gamma p_A}{\varepsilon_p}[\gamma-(\gamma-1)(1+\frac{8\mu}{i\omega L_{th}^2\,\mathrm{Pr}\,\rho_f}\sqrt{1+\frac{i\omega L_{th}^2\,\mathrm{Pr}\,\rho_f}{16\mu}})^{-1}]^{-1}$$

$$\rho_{rig}=\frac{\tau\rho_f}{\varepsilon_p}[1+\frac{R_f\varepsilon_p}{i\omega\rho_f\tau}\sqrt{1+\frac{4i\omega\tau^2\mu\rho_f}{R_f^2L_v^2\varepsilon_p^2}}],L_v=\frac{1}{s}\sqrt{\frac{8\mu\tau}{\varepsilon_p R_f}}$$

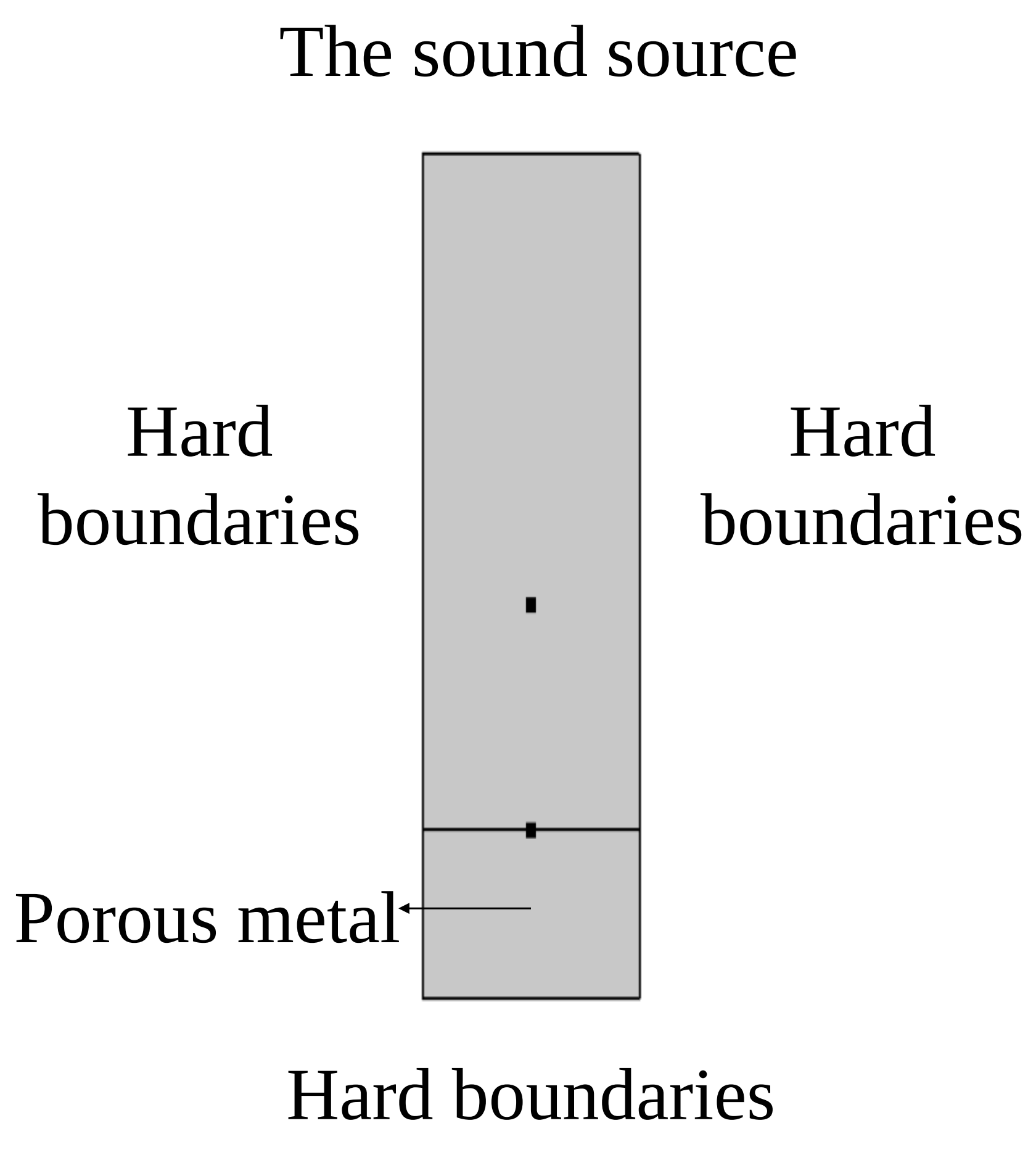

Figure 2 The geometric model

Variables	Figure	Units
porosity	1000	1
static flow resistivity	10500	Pa*s/m^2
tortuosity factor	1.0059	1
nonlinear coefficient	5100	kg/m^{-4}

Table 1 The structural parameters of the porous metal

Results:

a. The comparison of the sound pressure level in the tube at the incident sound pressure level 90dB and 155dB.

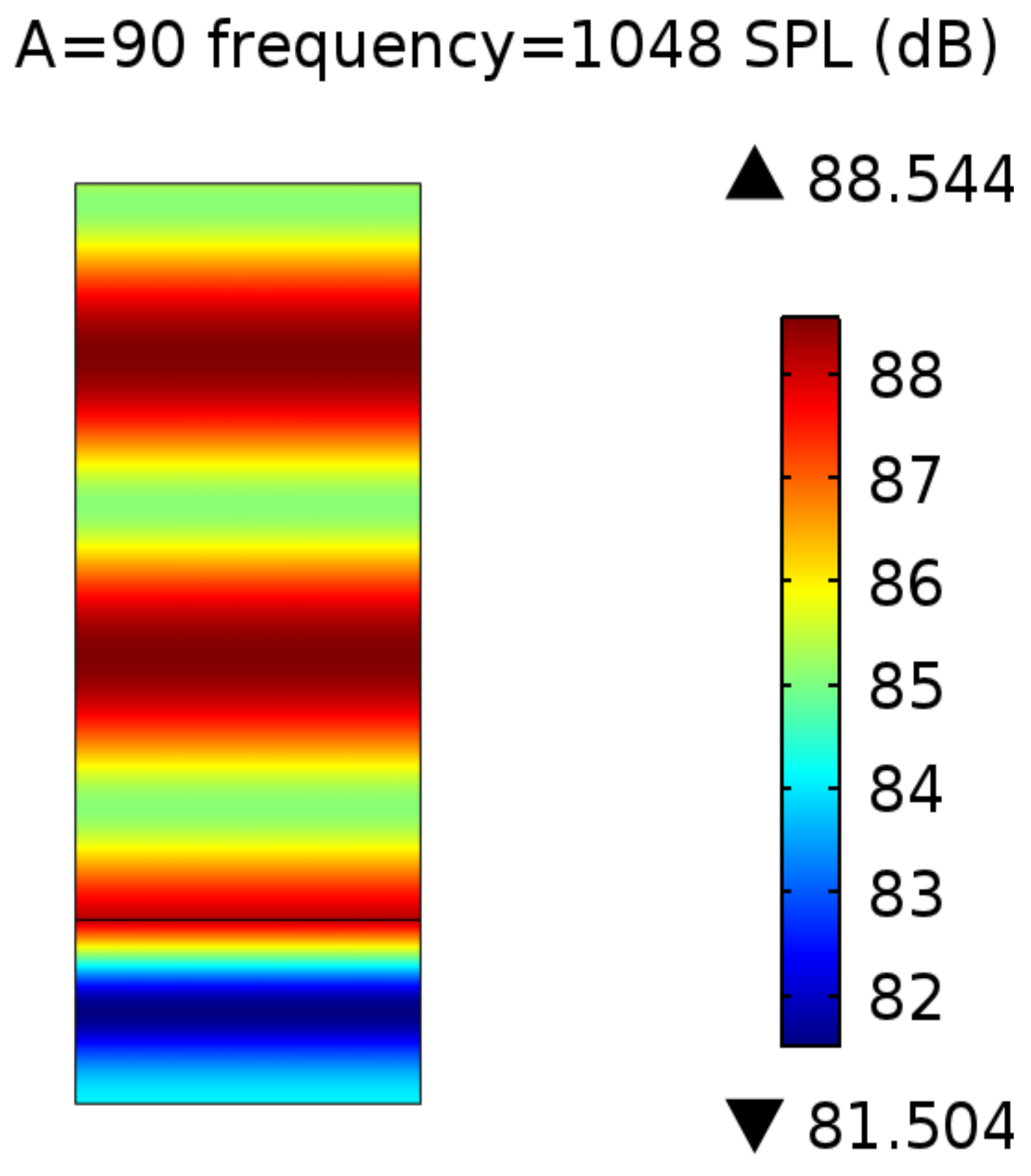

Figure 3 The geometric model

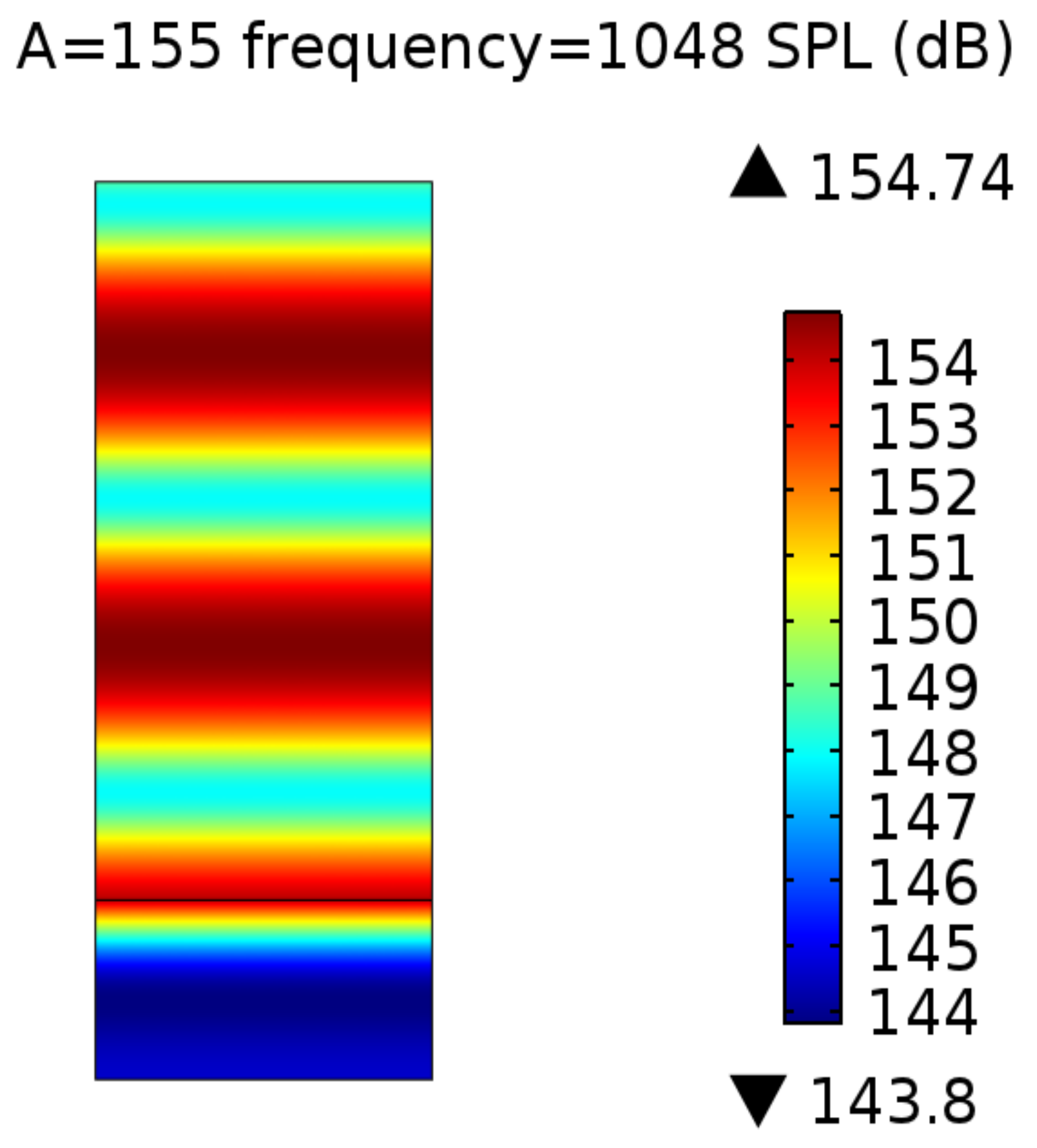

Figure 4 The geometric model

b. The sound absorption coefficient with respect to frequency and sound pressure level respectively

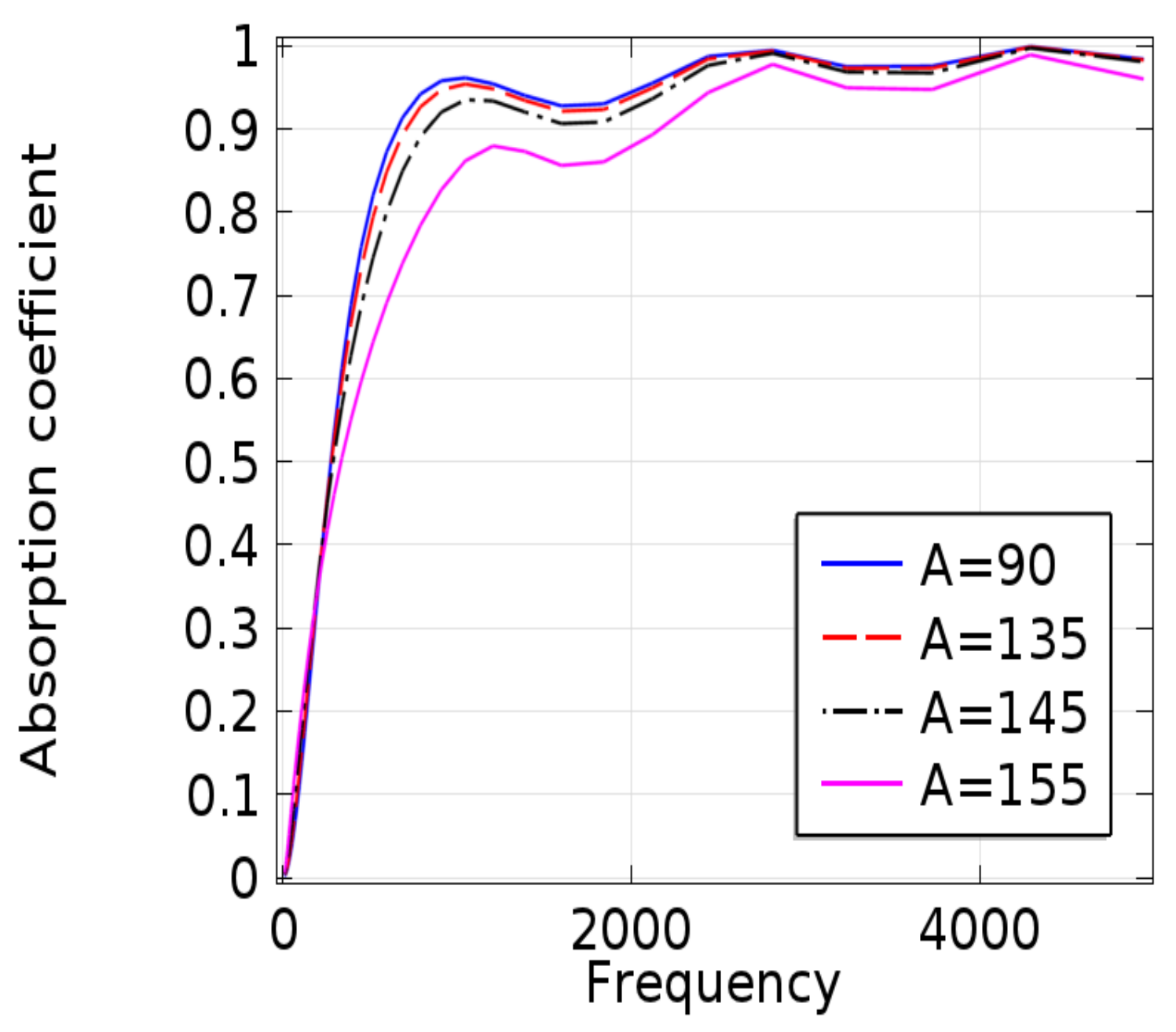

Figure 5 Sound absorption coefficient of porous metal with respect to frequency

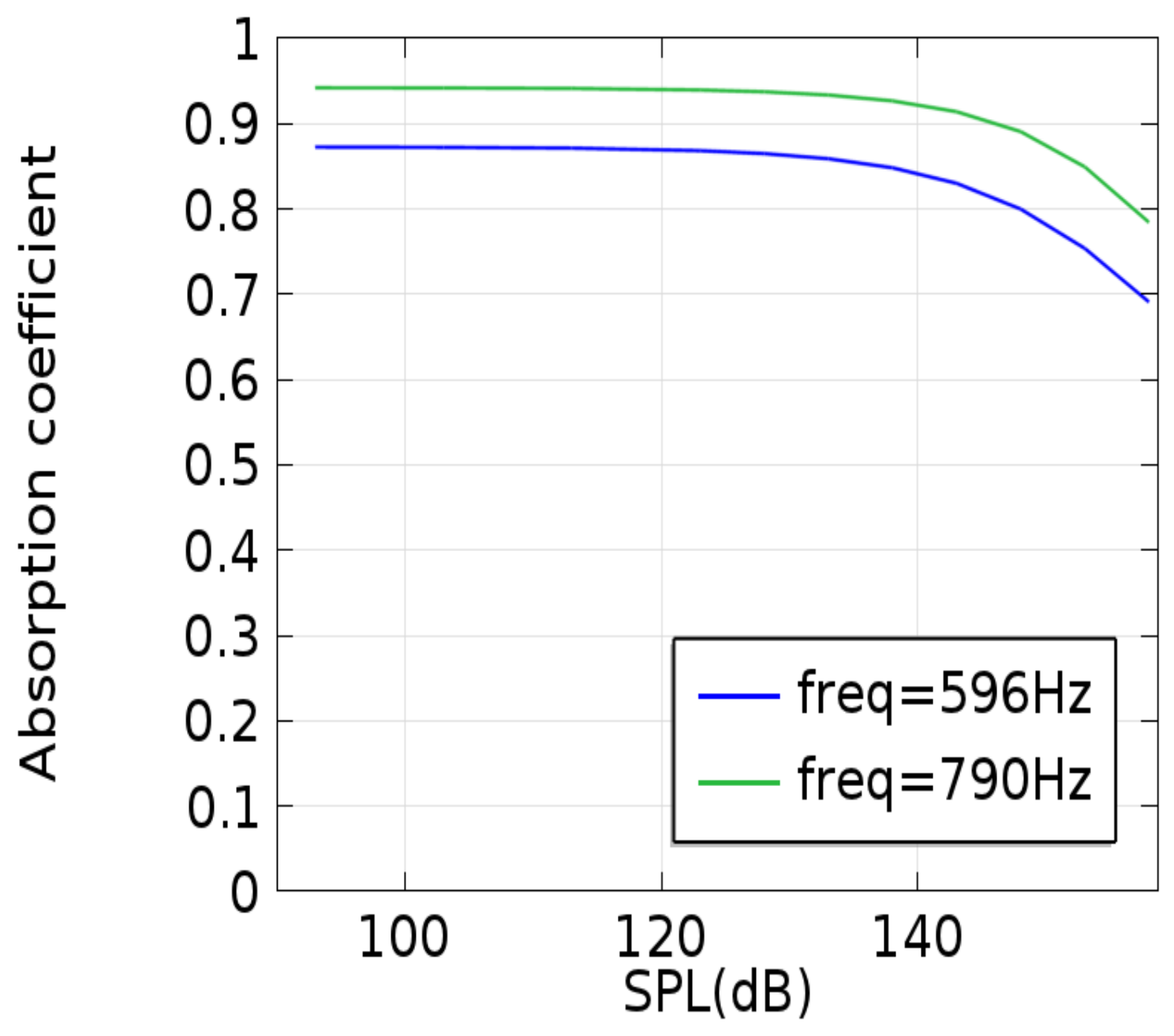

Figure 6 Sound absorption coefficient of porous metal with respect to SPL

Conclusions:

At different high sound pressure levels, the absorption coefficient of porous metals will be weakened as the incident sound pressure level increases; whereas its sound absorption coefficient varies apparently with respect to the frequency. For a fixed frequency and lower SPL, the sound absorbing property almost keep constant.

References:

1. Rademaker, E. R., Vand der Wal, H.M.M., Geurts, E.G. M., Hot-stream in-situ acoustic impedance measurements on varies air-filled cavity and porous liners, The 16th International Congress on Sound and Vibration, Krakow, Poland, 5-9 July, (2009).
2. Zhou H., Wu J. H., et al. Acoustic Properties of Porous Metals at High Temperature and High SPL, Chinese Journal of Theoretical and Applied Mechanics, 45(2), 229-235, (2013).
3. COMSOL Inc., Acoustics Module User's Guide, Version 4.3, (2012)
4. Nordin P., Sarin S. L., Rademaker, E. R., Development of new linear technology for application hot stream areas of aero-engines, Proc. 10th AIAA/CEAS Aeroacoustics Conference, 1-13, (2004).

COMSOL CONFERENCE 2015 北京
Excerpt from the Proceedings of the 2015 COMSOL Conference in Beijing