Response to reviewer#2

Thanks for the reviewer's helpful comments on the manuscript. The point-by-point responses are listed below.

Comment: *This manuscript conducted DMA-SP2 measurements at three sampling sites in China and investigated the microphysical properties of BC-containing particles, including mixing state and morphology. The valuable and high-quality measurement data presented in the manuscript will help better understand BC properties in the different atmospheres in China, which is of great interest to the scientific community. Therefore, I recommend this manuscript for publication, as long as the following comments are properly addressed.*

Reply: Thanks for the comments.

Comment: *Some sentences in the abstract seem to be redundant. Please try to make it concise.*

Reply: Thanks for the comments. We simplified some of the sentences in the abstract.

Comment: *Line 62, I think this classification is scientifically inappropriate. There are also other types of BC particles, such as fresh fractal-shape aggregates, partially coated, etc.*

Reply: Thanks for the comments. We have changed the classification of BC particles into thinly and thickly coated ones. For the thickly coated BC, it can be further divided into two morphological types: bare BC on the surface of non-BC particles or partially coated (attached type) and BC embedded within or coated by non-BC components (coated type).

Comment: *In the section of Part 3.1, the authors provide a detailed introduction of the three measurements, including the meteorology, gaseous pollutants, and PM2.5 pollution features. However, such information is not related to the topic of the manuscript, nor any of the discussion in the following parts. It is suggested that this part is simplified and focuses on what is related to the topic.*

Reply: Thanks for the comments. We simplified section 3.1 in the manuscript.

Comment: *Line 209, why in this study a different lag time (1.4 us) was used?*

Reply: Thanks for the comments. Two log-normal distributions were used for the probability distribution of the lag time for BC-containing particles:

$$\mathrm{PDF}(\Delta t) = \sum_{i=1,2} \frac{A_i}{\sqrt{2\pi}\log(\sigma_{g,i})} exp\left[-\frac{\log(\Delta t)-\log(\Delta t_i)}{2log^2(\sigma_{g,i})}\right],$$

Where Δt is the lag time, A_i, $\sigma_{g,i}$, Δt_i are the scale factor, geometric standard deviation, and geometric mean lag time of mode i respectively. The lag time was determined by calculating the value when the probability distribution values of mode 1 and mode 2 are equal. Figure R1 gives the probability distribution of the lag time

for the LJ site and the critical value of lag time was 1.4 μs. The critical lag time of 1.3 and 1.7 μs were determined for CP and PKU sites, respectively.

Some values were slightly changed accordingly due to the use of different lag times in the manuscript. We replotted figure 2 in the manuscript.

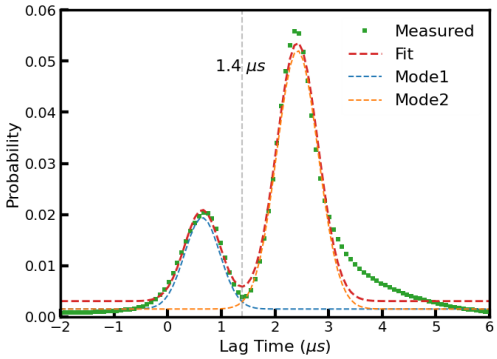

Figure R1. Lognormal fit (two modes) examples of the lag time distribution during the campaign for the LJ measurement site. The green squares, red dashed line, blue dashed line, and orange dashed line represent the measured lag time distribution, the fit results of the lag time distribution, fit results of mode 1, and fit results of mode 2, respectively.

Comment: *Line 228, "the CP site is not far from the urban, and thus the fresh BC particles from the traffic contribute a large amount of the total ones." This part confuses me. Why the CP site instead of the urban site (PKU) is dominated by traffic emissions?*

Reply: Thanks for the comments. We do not mean that the CP site instead of the urban site (PKU) is dominated by traffic emissions.

The difference in the number fraction of the thickly coated BC particles was synthetically influenced by the ambient pollution levels and the sources of the BC aerosols. The suburban site CP had the largest number fraction of the thinly coated BC particles. The CP site is not far from the urban, and thus the thinly coated BC particles from the traffic contribute a large amount of the total ones. The urban site PKU had a larger number fraction of the thickly coated BC than that of the CP site. This might be resulted from the PKU site being more polluted than the CP site and then the aging processing at the PKU site was faster than that at the CP site.

Comment: *Line 332, is electron microscopy data from this study or the previous study (Moteki et al., 2014)? If it is from the previous study, is the conclusion representative of the situation in this study?*

Reply: Thanks for the comments. The number fraction of attached BC particles from Moteki et al. (2014) is from the measurement of SP2, which adopted the same method as our studies. Therefore, the number fraction of attached BC particles can be used to compare with our studies.

Comment: *Figure 4, which sampling site is discussed here?*

Reply: Thanks for the comments. The data in figure 4 corresponds to the CP site. We added descriptions in the corresponding texts.

Moteki, N., Kondo, Y., and Adachi, K.: Identification by single-particle soot photometer of black carbon particles attached to other particles: Laboratory experiments and ground observations in Tokyo, Journal of Geophysical Research: Atmospheres, 119, 1031-1043, https://doi.org/10.1002/2013JD020655, 2014.