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# *Interactive comment on* "Density changes of aerosol particles as a result of chemical reaction" *by* Y. Katrib et al.

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**Comment 1: $\mathrm{Pd}$ formulation vs. $\mathrm{Kn}$ formulation**
The formulation of the "vacuum" or "atmospheric" condition is important since it is flow regime which determines the interaction of the particle with the suspending gas, and hence the drag on the particle. Typically flow regimes are divided into 3 general categories, the continuum regime, the free molecular regime, and the transition regime. The Knudsen Number ($Kn$) is typically used to determine the flow regime (e.g. Seinfeld and Pandis 1998; Hinds 1999; Baron and Willeke 2001). Characteristic values for the different regimes are found in the table below with the corresponding $Pd$ (formulation in this manuscript page 6436 line 9) values:

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| Continuum Regime | Transition Regime | Free Molecular Regime |
|---|---|---|
| $Kn < 0.1$ | $0.1 < Kn < 10$ | $Kn > 10$ |
| $Pd > 130$ | $130 > Pd > 1.3$ | $Pd < 1.3$ |

The authors describe two regimes: $Pd << 1$ for “vacuum conditions”, and $Pd >> 1$ for “atmospheric conditions”. These definitions are incorrect, since the mid-point between the regimes is at $Pd \sim 13$, not $Pd = 1$. E.g. according to their definition one would expect the free moleculear regime to start around $Pd \sim 0.1$, but $Pd = 1.3$ is a more accurate starting point of the free molecular regime. Similarly $Pd \sim 10$ would approximately mark the start of the continuum regime in the formulation in the paper. However $Pd \sim 10$ corresponds to $Kn \sim 1.3$, which is right in the middle of the transition regime.

In summary the use of $Pd$ is not standard, not dimensionless, prone to confusion, and not accurate with the limits given in the paper. For these reasons we suggest that the paper is revised using $Kn$ instead of $Pd$.

### Comment 2: Ratio of Slip Correction Factors

The separation of shape and slip correction on page 6436 line 13 is followed on line 15 with bounds $(Pd >> 1)$ for when the correction $\phi = 1$ and can be neglected. This formulation is in error, due to the error pointed out in comment 1 above. Below are 2 numerical examples of the error in this formulation:

*First example*: let’s assume a mildly irregular particle $\chi^{shape} = 1.25$ with a $d_m$ of 100 nm $(Pd = 10)$. An exact calculation of the corresponding volume equivalent diameter $(d_{ve})$ yields a value of 88 nm.

Exact Equation:

$$\frac{d_m}{C_c(d_m)} = \frac{d_{ve} \cdot \chi^{shape}}{C_c(d_{ve})}$$

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Setting $\phi$ to 1 and canceling out the Cunningham Slip Correction factors (as is the method in this manuscript) yields a value of 80 nm. This is a $\sim 10\%$ error in the diameter, but if this diameter were then used to calculate a corresponding particle volume, the error is cubed and becomes $\sim 25\%$.

*Second example*: a very irregular soot particle with $\chi^{shape} = 2.5$ has a $d_m$ of 300 nm ($Pd = 30$). An exact calculation of $d_{ve}$ yields 160 nm. The approximation method presented in this manuscript yields a value of 120 nm. The error in the diameter measurement is 25%, and the volume error would be 58% (i.e., the volume would be underestimated by more than a factor of 2).

This formulation is also used to derive parts of Tables 1 and 2 (pages 6461 and 6462, respectively) in the appendix and some of the subsequent equations in the text (e.g. Equations. 1b and 2a), and thus they are consequently in error as well. A more systematic derivation of relationships between mobility and aerodynamic diameters is presented in DeCarlo et al. (AS&T, in press, which is referenced in this manuscript).

Since the experimental data in this paper involves spherical particles the issues raised here will not affect the interpretation of the experimental results presented in this paper. However, if this theoretical formulation is applied to non-spherical particles, large errors will result.

**Minor Comments**

- Page 6437 lines 23-25 seems to imply that the critical orifice is the location at which particles are imparted a size dependant velocity, inversely related to the aerodynamic diameter. Particles are actually imparted a size dependant velocity at the nozzle expansion at the end of the aerodynamic lens system. Please correct this in the text.

- Page 6438, line 2. It is stated here that the chopper used has a duty cycle of

0.05%. This is an extremely small duty cycle compared to what is typically used in the AMS (we are not aware of the use choppers smaller than 0.5%) and would be very difficult to fabricate.

## References

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