11B.8 ASSESSMENT OF THE DDA ALGORITHM FOR COMPUTING THE BACKSCATTERING FROM OBLATE WITH EXPERIMENTAL OBSERVATIONS¶

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1. INTRODUCTION

Discrete Dipole Approximation (DDA) has been a very important theoretical method for studying the scattering characteristics of a particle whose shape may be arbitrary and dielectric property inhomogeneous (Draine and Flatau, 1994).

It has long been known that falling raindrops larger than 140μm appear as oblates in general and most of hails can be approximated with oblates (Mishchenko et al., 1999). Thus, understanding the scattering characteristics of liquid water and ice oblates in microwave band is very important. In this study, DDA is used to calculate the back-scattering cross-sections of a series of oblates which are constructed for experiments in microwave laboratory for measuring back-scattering cross-sections. A comparison between the computed results and those from the experiments are made.

2. Oblate series for the study

The oblate sizes for the lab experiments and calculations are given in Tables 1 and 2.

Table 1 The size parameters of water oblates

Oblate	1	2	3	4	5	6
Length of the minor axis (cm)	0.23	0.28	0.34	0.46	0.60	0.66
Length of the major axis (cm)	0.35	0.42	0.49	0.64	0.78	0.93
Axis ratio	0.66	0.68	0.69	0.72	0.77	0.71
Equi-volume R_e (cm)	0.305	0.369	0.433	0.574	0.715	0.83

Table 2 The size parameters of ice oblates

Oblate	1	2	3	4	5	6	7	8
Length of the minor axis (cm)	0.19	0.37	0.42	0.52	0.60	0.63	0.74	0.86
Length of the major axis (cm)	0.20	0.40	0.60	0.58	0.80	0.88	1.00	1.21
Axis ratio	0.95	0.93	0.7	0.9	0.75	0.72	0.74	0.71
Equi-volume R_e (cm)	0.197	0.39	0.533	0.56	0.727	0.789	0.906	1.08

3. RESULTS FROM LAB EXPERIMENTS AND COMPUTATIONS

The measuring system and the oblate sampling method for lab experiment have been described by Wang et al.(1998). Three typical wavelengths such as 3.2cm(X band), 5.6cm(C band) and 10.7cm(S band) are used and the refractive indices of water are 7.81+2.42i, 8.6204+1.674i and 9.0063+0.9531i, respectively. The refractive index of ice in the bands is taken as a constant of 1.78+0.0024i. Let the number of dipoles *N*=(32, 32, 32*axis ratio) so that *N* is large enough to satisfy the DDA condition for all the oblates given in Tables 1 and 2.

The back-scattering cross-sections obtained from both lab experiments and computations are given in Fig. 1. It can be seen that they agree with each other quite well in general even though the relative error may be as large as 40% when Re is in the range of 0.5—0.6cm, as shown in Fig.1a. The agreement for ice oblates (as shown in Fig.1d, e, and f) is better than for water particles (as in Fig.1a, b, and c) because of the lower refractive index of ice.

Both lab measurements and computations show obviously the well-known fact that the Qb's for horizontal polarization are larger than those for vertical polarization in general. This is because that the major axis of oblate is horizontal while the minor axis is vertical. Thus in natural rainfall the ratio of Q_{bH}/Q_{bV} is always greater than 1. Though small ice crystals in cloud do not change this feature of the ratio, larger hailstones in oblate shape if existed in cloud and rainfall would lead to Q_{bH}/Q_{bV} <1and a negative Z_{DR}, which is defined as $Z_{DR} = 10\log(Q_{bH}/Q_{bV})$. This derivation is consistent with the literature.

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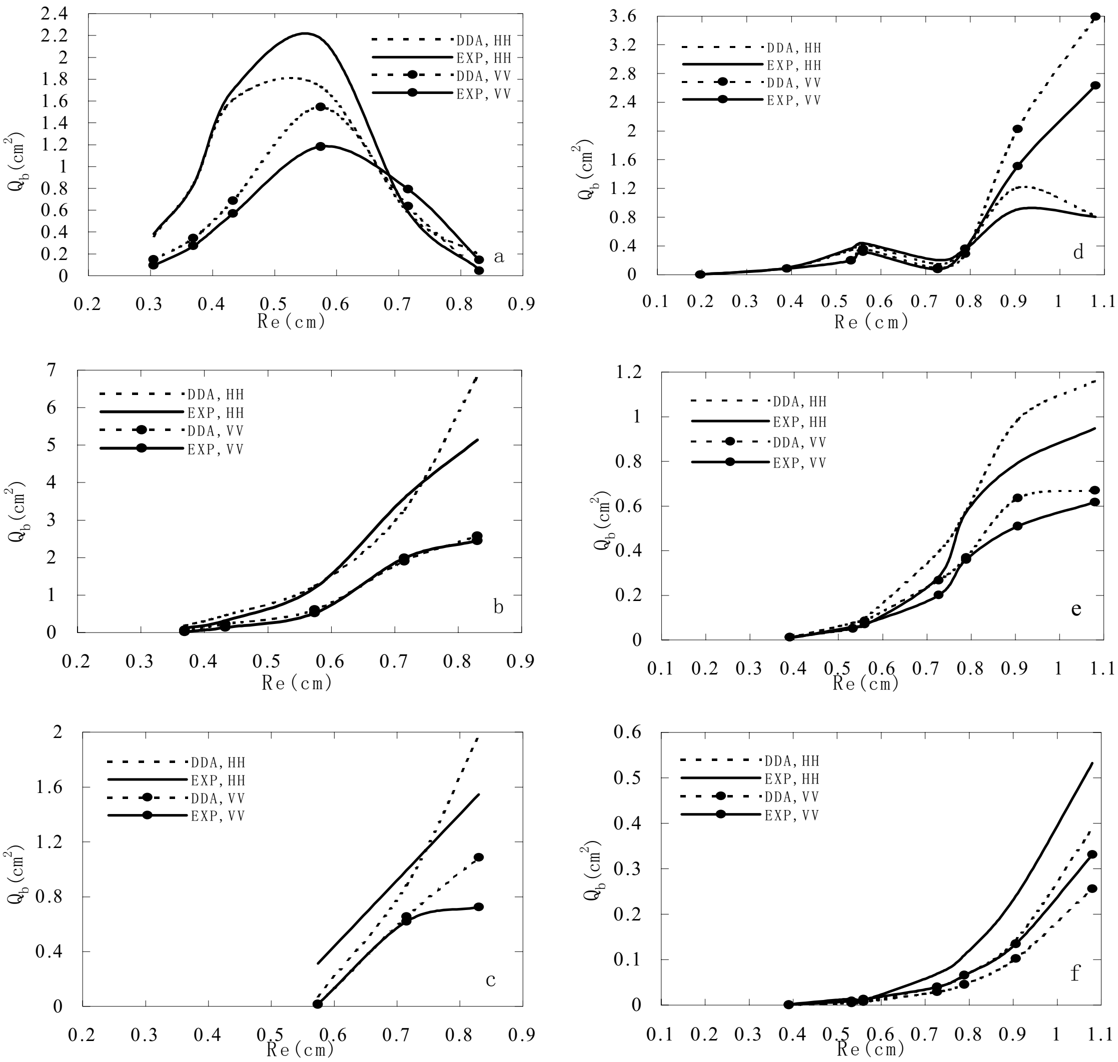

Fig.2 Backscattering cross section Q_b of oblates as a function of equi-volume radius Re. Panels a, b and c are for liquid oblates at X,C and S bands respectively. Panels d, e and f are the same as Panels a ,b and c, but for ice oblates. “DDA” stands for the Q_b‘s computed. “EXP” stands for the Q_b‘s from experiments. “HH” and “VV” means that the incident waves are horizontal and vertical polarized, respectively.)

4. CONCLUSION

Backscattering cross-sections of a series of water and ice oblates have been observed with lab facilities and computed with the discrete-dipole approximation (DDA) algorithm. A comparison of the observed and calculated results is made and, as expected they are in quite good agreement with each other even though differences exist.

The consistence between the results from the lab experiments and computations shows that the DDA software in hand can be used in research on scattering characteristics of oblate hydrometeors which are typical in cloud and rainfall.

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