DDA Calculations of Sector Snowflake Single Scattering Properties

Robin Ekelund, Patrick Eriksson

Chalmers University of Technology, Sweden

3rd ISMAR Workshop, Paris, 28-29 September

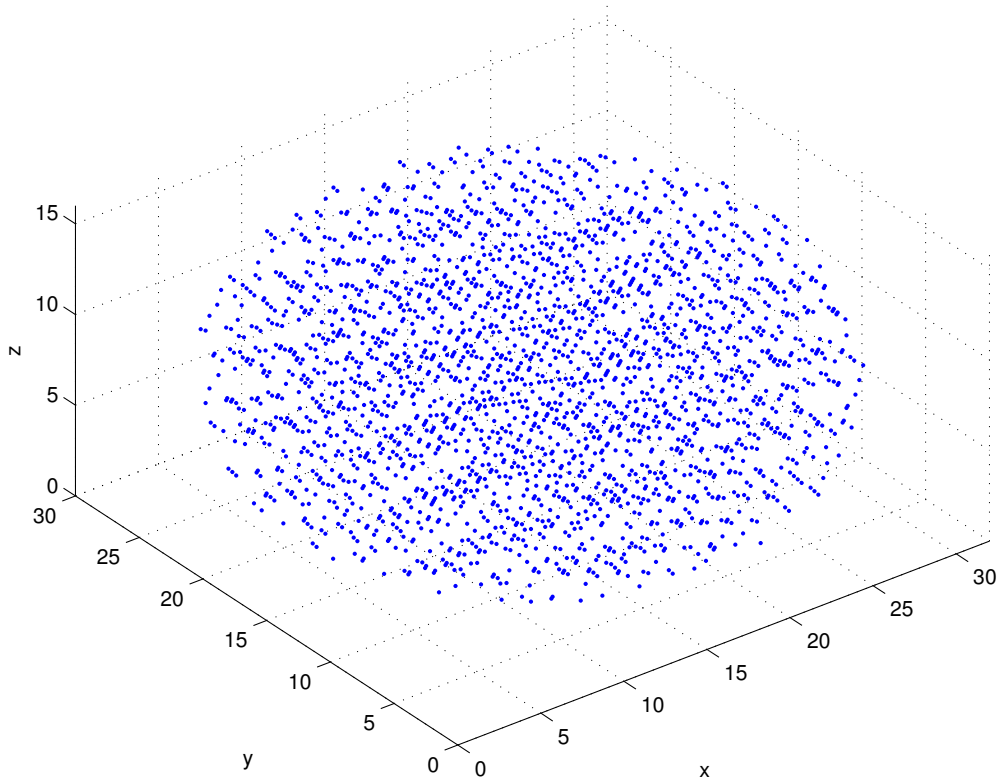
Outline

What is DDA?

Discrete Dipole Approximation,

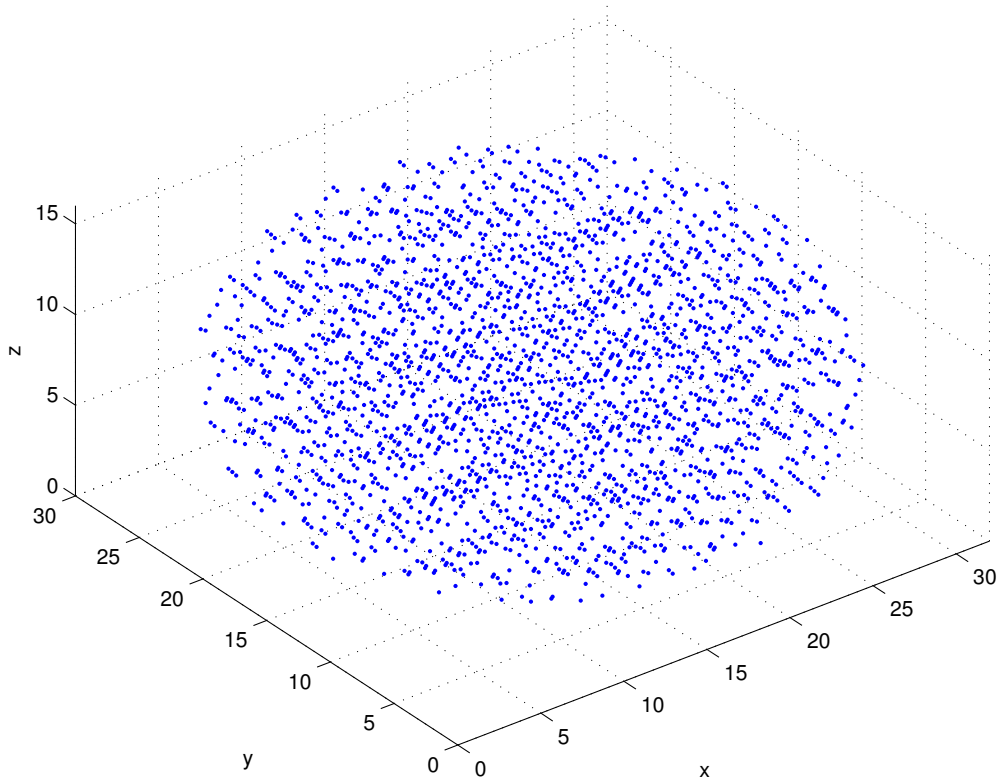
What is DDA?

Discrete Dipole Approximation,



What is DDA?

Discrete Dipole Approximation,



$\overline{\alpha}_i^{-1}\mathbf{P}_i - \sum_{j\neq i}\overline{\mathbf{H}}_{ij}\mathbf{P}_j = \mathbf{E}_i^{inc}$, Draine and Flatau (1994).

Motivation

TRRM Microwave Sounder
ECMWF (soft sphere vs DDA sector flake)

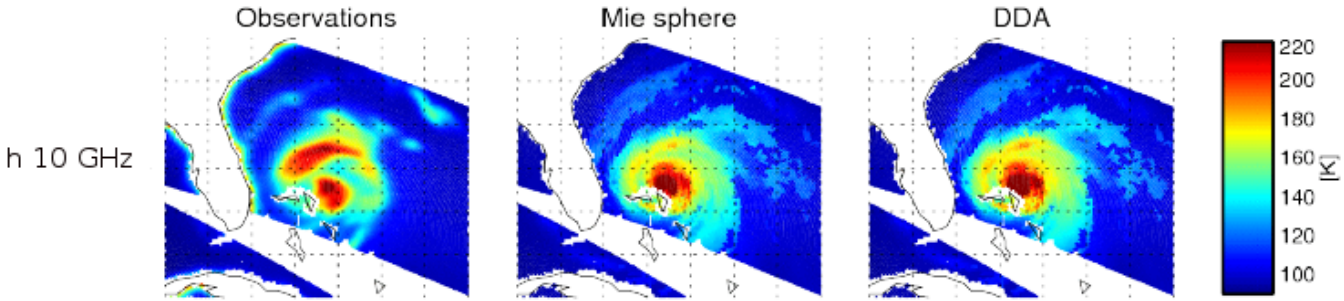


Figure : Geer and Baordo (2014).

Motivation

TRRM Microwave Sounder
ECMWF (soft sphere vs DDA sector flake)

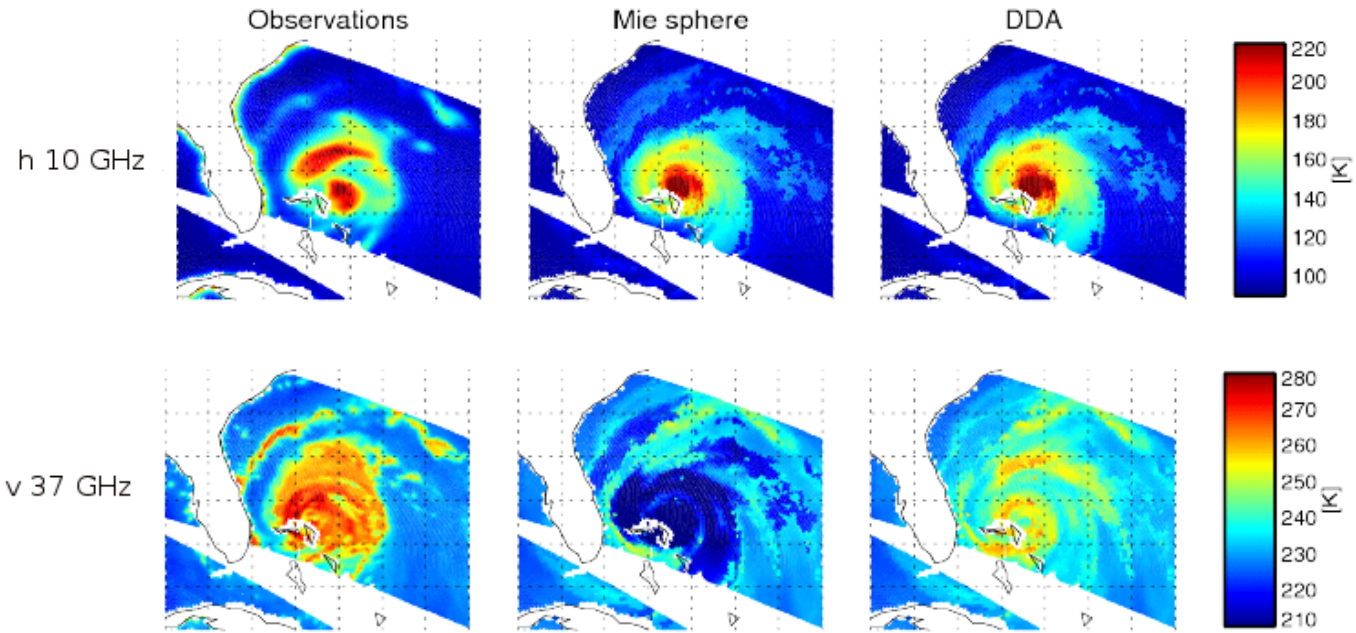


Figure : Geer and Baordo (2014).

Current Situation

- Hong et al. (2009).
- Liu (2008).

Specifications (Hong):

- Outdated refractive index, Warren (1984).
- Temperature, 243 K.
- D_{max}, 2 to 2000 μm.
- Frequencies, 85 to 880 GHz.

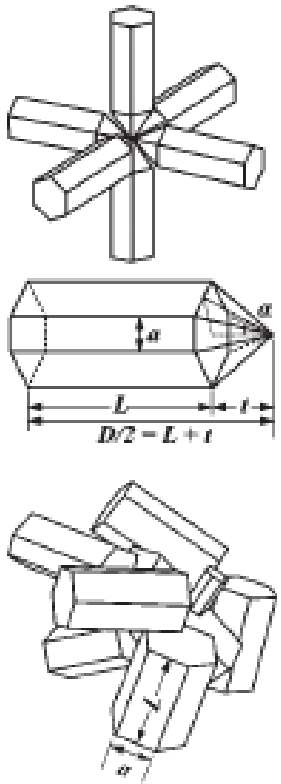


Figure : Hong et al.(2009)

Current Situation

- Hong et al. (2009).
- Liu (2008).

Specifications (Liu):

- Refractive index, Mätzler (2006).
- 5 Temperatures, 233 to 273 K.
- D_{max}, 2 to $12000\,\mu\mathrm{m}$.
- Frequencies, 13 to 340 GHz.

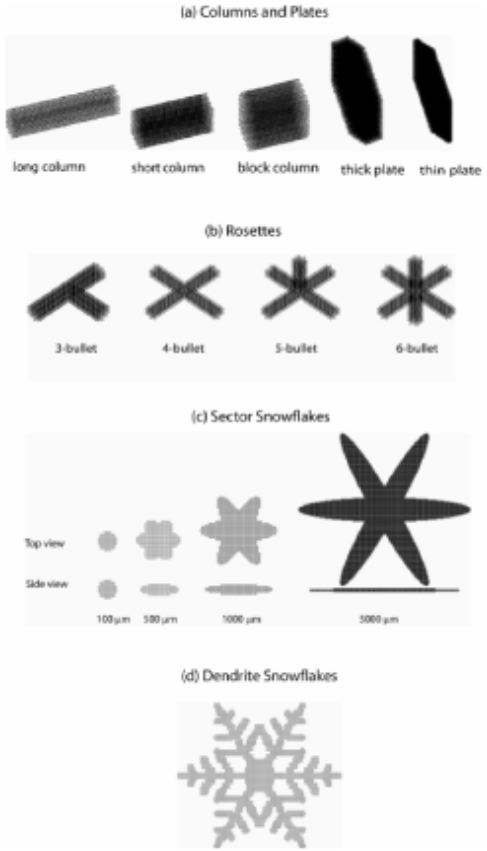


Figure : Liu (2008)

Specifications

- Completely randomly oriented sector snowflakes. Geer and Baordo (2014), Eriksson, et al. (2015).
- ARTS SSP format.
- Refractive index taken from Mätzler (2006).
- ISMAR, MARSS and ICI frequencies, up to 664 GHz.
- Temperatures,
  T = 203, 233, 253, 273K.
- 41 sizes,
  $D_{max} = [20\mu\text{m}, 1.25\text{cm}]$.
- Scattering angle from $0°$ to $180°$, steps of $1°$.
- Calculations performed by *Amsterdam DDA* (ADDA), Yurkin (2007).

Frequencies

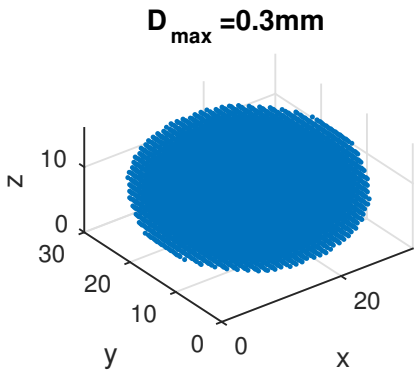
Channels (GHz)	Subbands (GHz)	Instrument
88.992	± 1.1	MARSS
94		CLOUDSAT
118.750	± 1.1 ± 1.5 ± 2.1 ± 3.0 ± 4.0	ISMAR
157.075	± 2.6	MARSS
183.248	± 0.975 ± 3.0 ± 7.0	MARSS, ICI
243.200	± 2.5	ISMAR, ICI
325.15	± 1.5 ± 3.5 ± 9.5	ISMAR, ICI
448.00	± 1.4 ± 3.0 ± 7.2	ISMAR, ICI
664.00	± 4.2	ISMAR, ICI

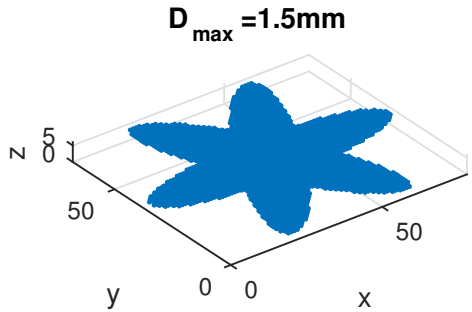
Shape parametrization

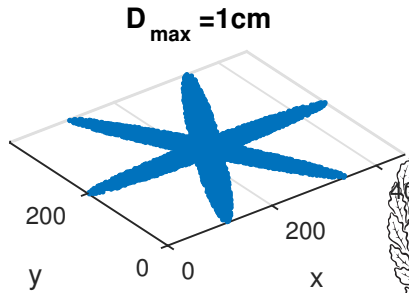
Mass-Size relationship

$$\begin{cases} A_r &= 0.261 D_{max}^{-0.377} \\ \rho_e &= 0.015 A_r^{1.5} D_{max}^{-1.0} \end{cases} \Rightarrow \qquad m = 0.775 D_{max}^{1.43} \text{ (cgs)}$$

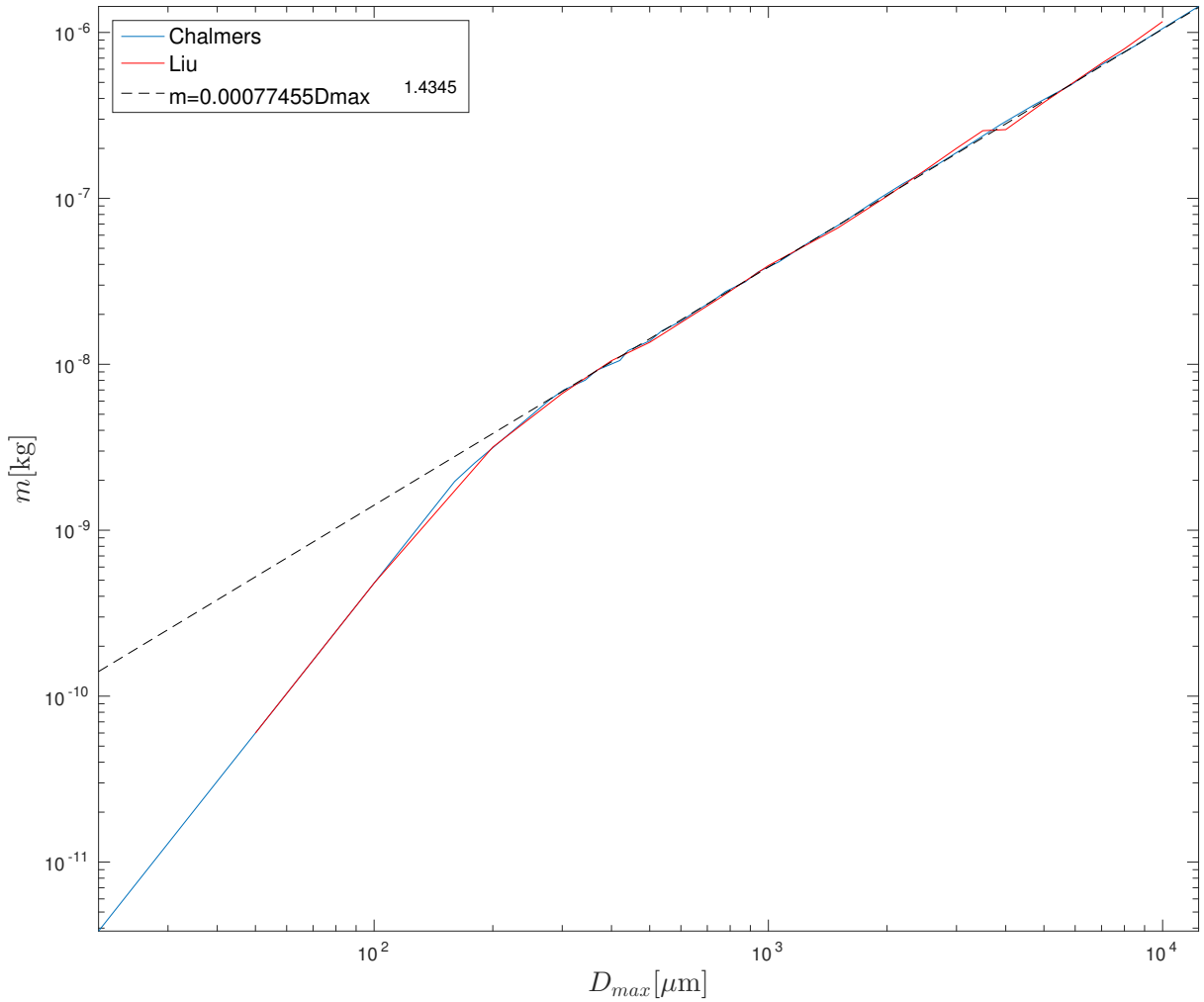
Heymsfield (2002, 2003).







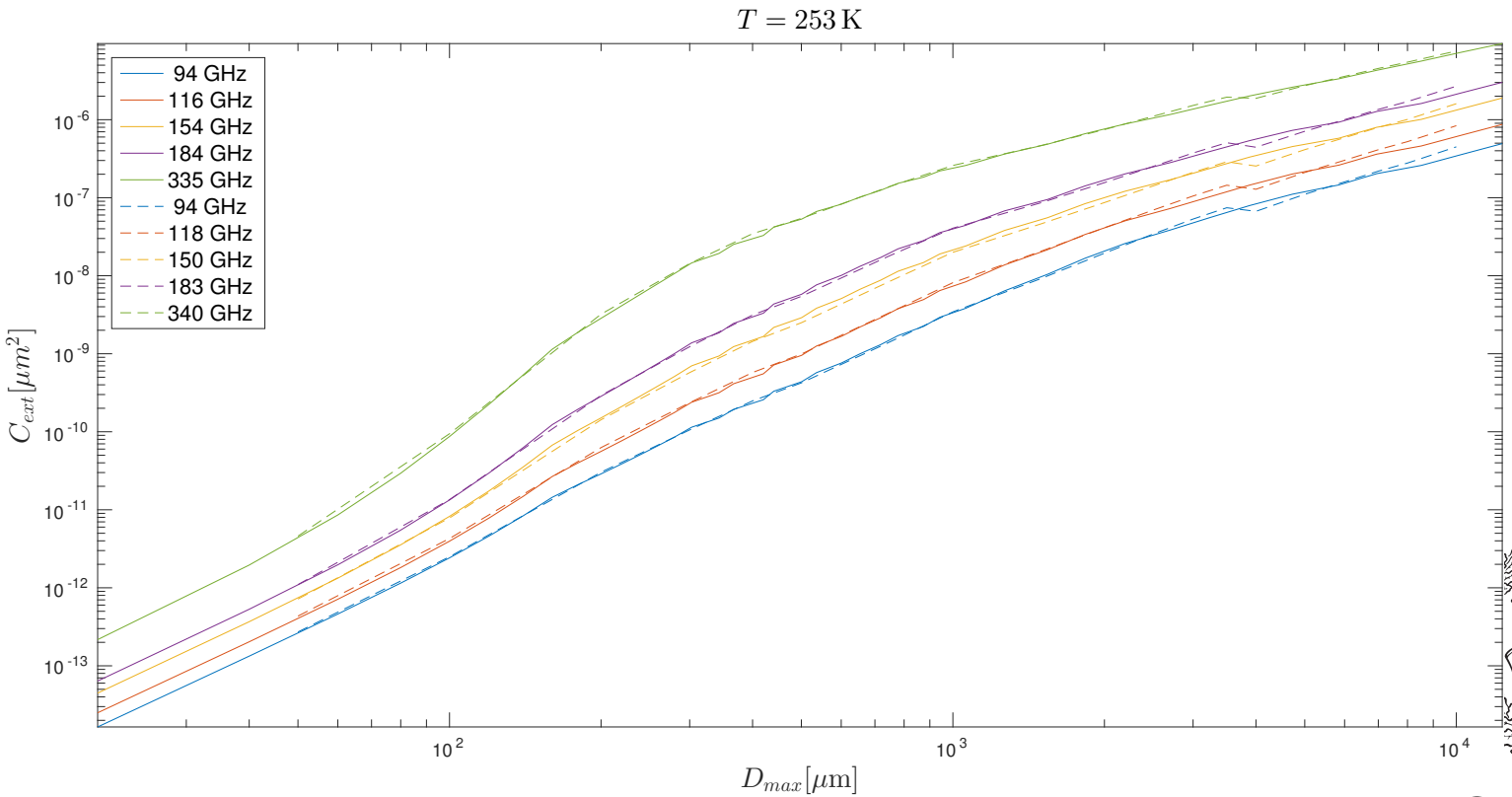
mass-size relationship



Extinction

Chalmers —

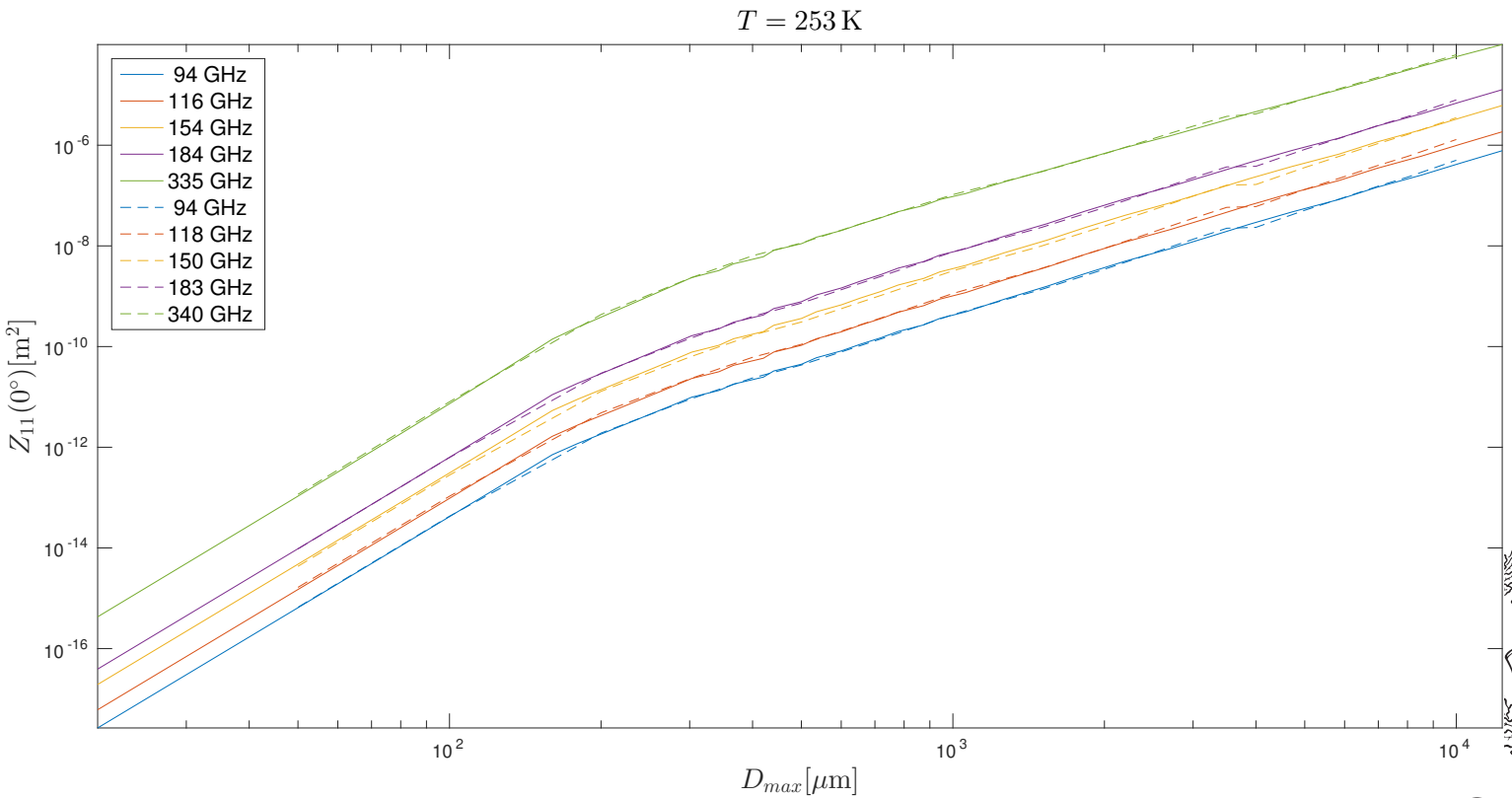
Liu - -



Forward scattering

Chalmers —

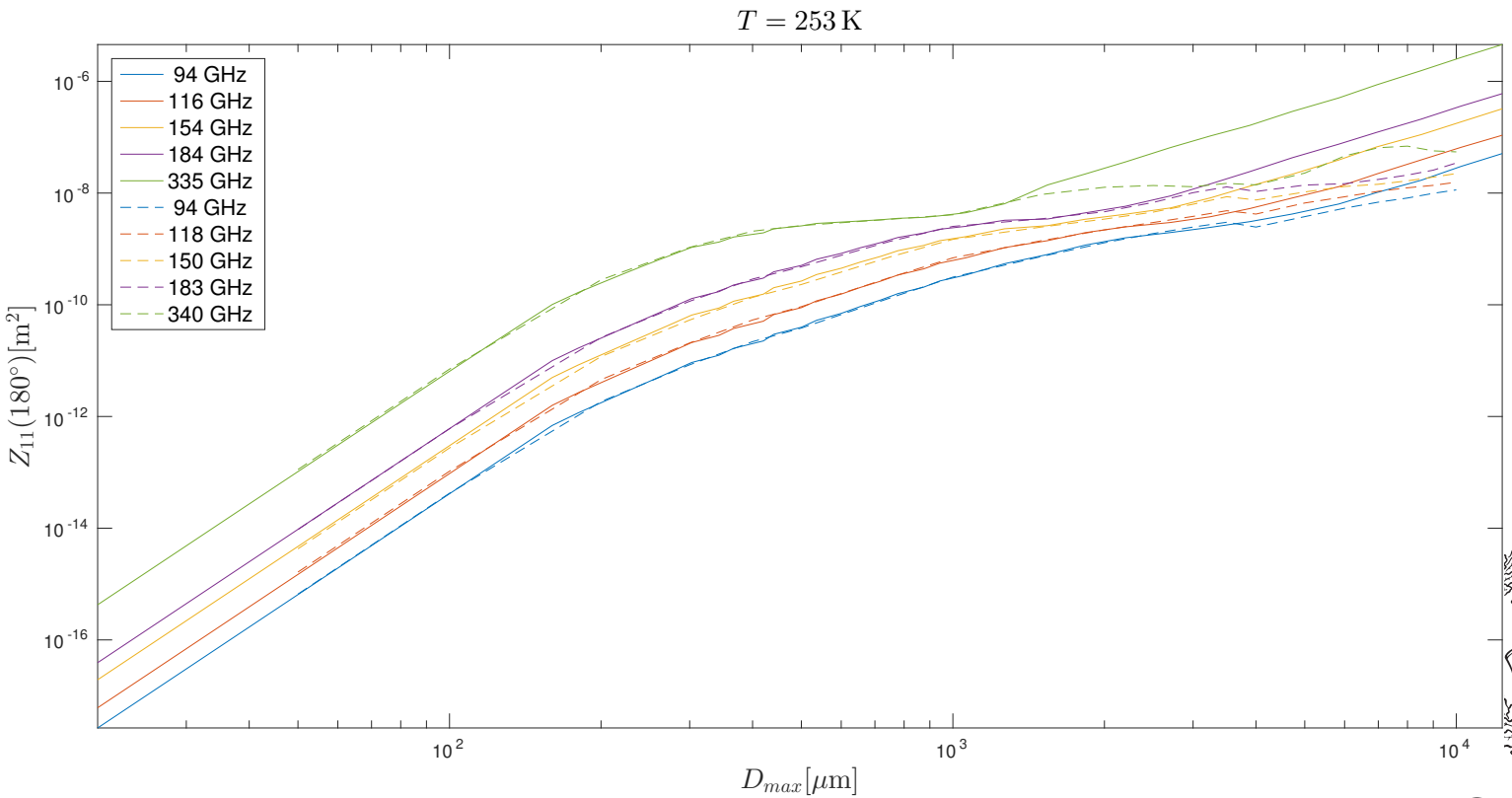
Liu - -



Backward scattering

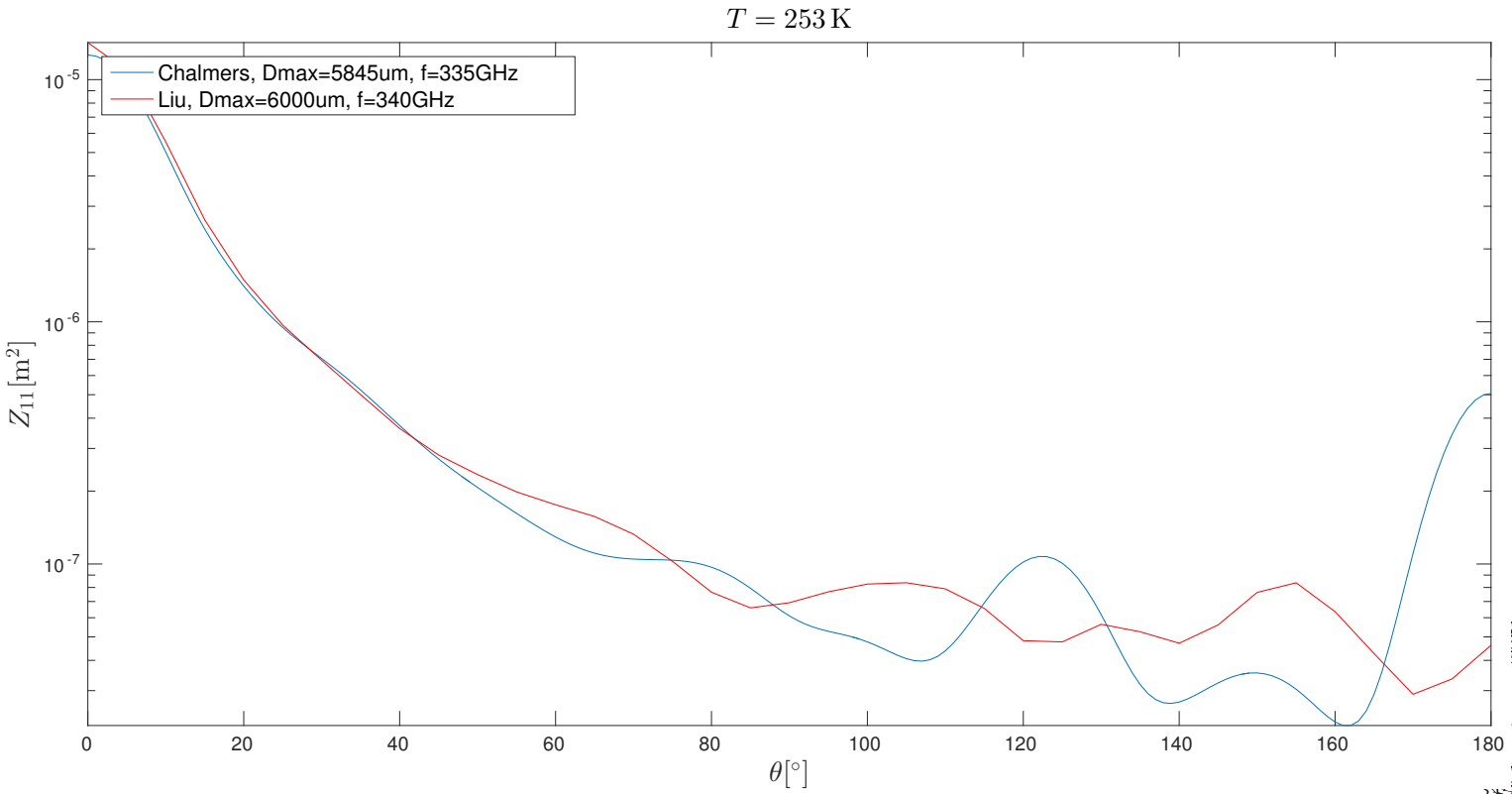
Chalmers —

Liu - -



CHALMERS
UNIVERSITY OF TECHNOLOGY

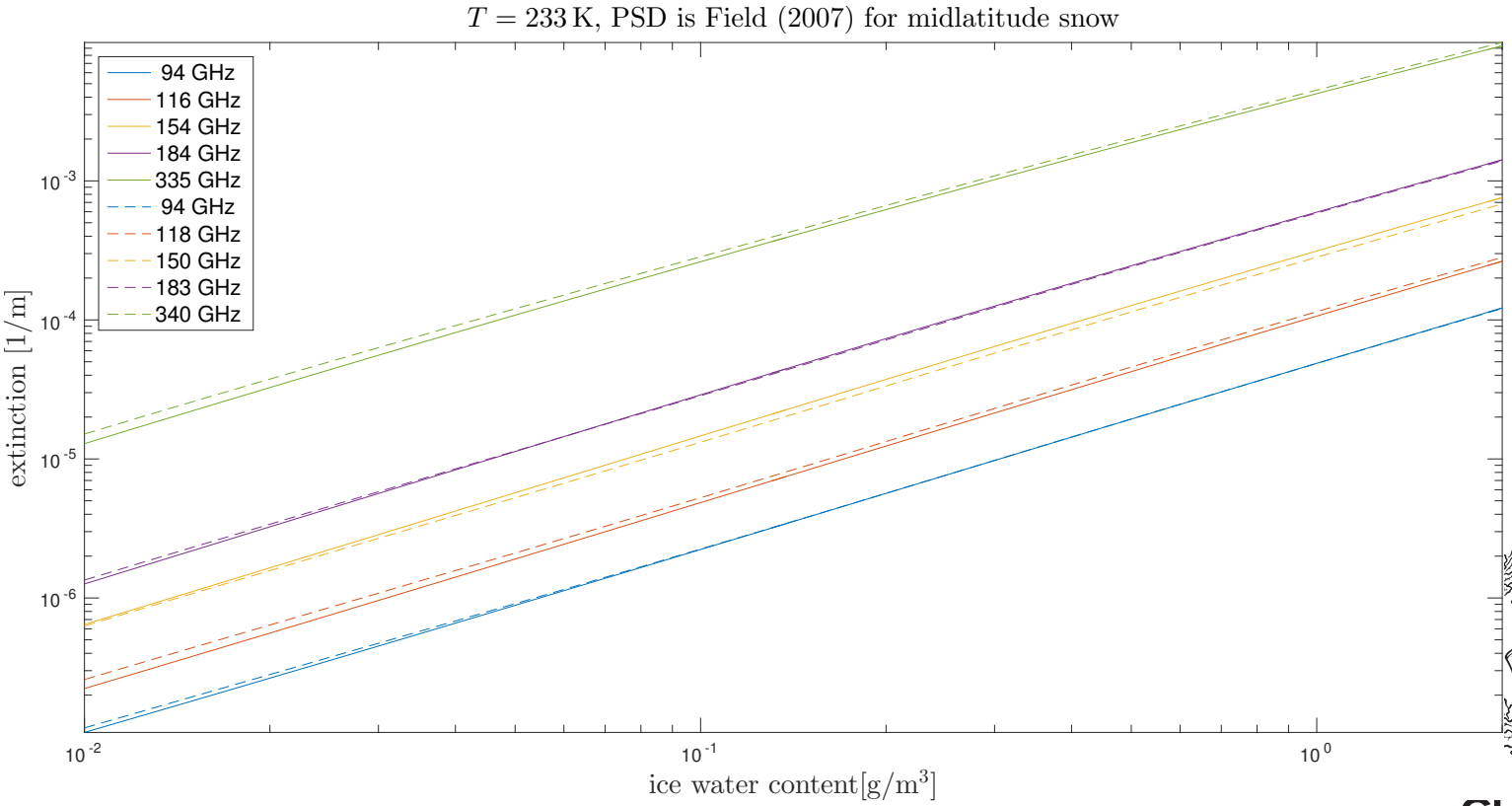
Scattering angle dependence



CHALMERS
UNIVERSITY OF TECHNOLOGY

Integrated extinction

Chalmers —
Liu - -



CHALMERS
UNIVERSITY OF TECHNOLOGY

- Additional frequencies:
  874 GHz,
  3, 5, 9, 10, 13.4, 15, 19, 24.1, 35.6, 50, 60, 70, 80, 85.5 GHz,
  further requests?
- Additional shapes.
- Horizontal orientation.

END

robin.ekelund@chalmers.se