A Digital Holographic Imager for Cloud Microphysics Studies

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I dedicate this thesis to my parents without whom none of this would have been possible

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Abstract

Clouds play a crucial role in regulating the climatic and meteorological systems of planetary atmospheres due to their impact on the radiative transfer of electromagnetic energy through the atmosphere and in governing the hydrological (or equivalent) cycles. The role of clouds is of particular interest within the Earth's atmosphere where they cover approximately 70% of the Earth's surface and also have an impact on aircraft safety considerations due to aircraft icing and associated hazards.

To quantitatively understand the influence of clouds in an atmospheric system, the underlying physics of their formation, evolution and interaction with other atmospheric dynamical processes must be observed and modelled. These processes are governed by the underlying microphysical cloud properties such as the cloud particle shapes, sizes, spatial clustering and thermodynamic phase. Direct observations of these microphysical properties have historically proved challenging with large discrepancies seen between the outputs of climate models and direct observations, suggesting a lack of understanding of these processes.

Digital holography is a three dimensional imaging technique that allows direct measurement of many microphysical observables, such as the particle size distribution, particle shape distribution and spatial distribution, making it an attractive solution to this observational challenge. Previous instruments have been expensive and heavy devices, limiting their use to ground based observations or on board expensive research aircraft flights, which has severely limited the amount of data obtained from these instruments. There is therefore a need for a low cost, light weight digital holographic instrument suitable for deployment on a tower structure or weather balloon to obtain these critically needed measurements in remote and widespread regions. The development of such an instrument is outlined in this thesis.

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