Astrophys Space Sci (2012) 342:31–43
DOI 10.1007/s10509-012-1151-1

ORIGINAL ARTICLE

g Dependent particle concentration due to sedimentation

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Received: 17 April 2012 / Accepted: 14 June 2012 / Published online: 13 July 2012

Abstract Sedimentation of particles in a fluid has long been used to characterize particle size distribution. Stokes' law is used to determine an unknown distribution of spherical particle sizes by measuring the time required for the particles to settle a known distance in a fluid of known viscosity and density. In this paper, we study the effects of gravity on sedimentation by examining the resulting particle concentration distributed in an equilibrium profile of concentration $C_{m,n}$ above the bottom of a container. This is for an experiment on the surface of the Earth and therefore the acceleration of gravity had been corrected for the oblateness of the Earth and its rotation. Next, at the orbital altitude of the spacecraft in orbit around Earth the acceleration due to the central field is corrected for the oblateness of the Earth. Our results show that for experiments taking place in circular or elliptical orbits of various inclinations around the Earth the concentration ratio $C_{m,n}/C_{m,ave}$, the inclination seems to be the most ineffective in affecting the concentration among all the orbital elements. For orbital experiment that use particles of diameter $d_p = 0.001$ μm the concentration ratios for circular and slightly elliptical orbits in the range $e = 0$–0.1 exhibit a 0.009 % difference. The concentration ratio increases with the increase of eccentricity, which increases more for particles of larger diameters. Finally, for particles of the same diameter concentration ratios between Earth and Mars surface experiments are related in the following way $C_{(m,n)_{Earth}} = 0.99962 C_{(m,n)_{Mars}}$.

Keywords Sedimentation · Planetary body · Microgravity · Oblateness coefficient · Acceleration of gravity · Van der Waals potential

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1 Introduction

Sedimentation of particles in a fluid has long been used to characterize particle size distribution. Stokes' law is used to determine an unknown distribution of spherical particle sizes by measuring the time required for the particles to settle a known distance in a fluid of known viscosity and density. Sedimentation can be either gravitational (1g-force), or centrifugal (many g-force). Gravitational sedimentation is normally limited to particles of relatively large size, because the rate of sedimentation for small particles is too low to give a practical analysis time, and because Brownian motion of small particles becomes too large to allow effective settling. A very narrow distribution of small particles will be reported as a broad distribution when the rate of particle diffusion is comparable to the sedimentation rate. Very small particles (<0.1 μm) never settle by gravity unless they are extremely dense, so most types of very small particles cannot be measured by gravitational sedimentation. Sedimentation in a centrifuge extends the range of sedimentation analysis to much smaller particles. High g-force makes