Colloids and the depletion interaction. The legacy of Asakura and Oosawa
Remco Tuinier$^{1,2,*}$ and Henk N.W. Lekkerkerker$^1$
$^1$Van ’t Hoff Laboratory for Physical and Colloid Chemistry, Debye Institute, Utrecht University, Padualaan 8, 3584 CH Utrecht, The Netherlands.
$^2$DSM Research, Advanced Chemical Engineering Solutions, P.O. Box 18, 6160 MD Geleen, The Netherlands

The physical properties of colloidal suspensions are strongly affected by the forces that act between the colloidal particles. Attempts to explain them in these terms go back to the beginning of the 20th century. Important and extensively studied forces in colloidal systems are Van der Waals forces, electrostatic forces and steric forces due to attached polymers. In the last decades it has been observed that the stability of colloidal particles is also affected by non-adsorbing polymers in solution [1]. The origin of this interaction was first explained successfully almost 60 years ago by S. Asakura and F. Oosawa using the concept that the free volume available to nonadsorbing polymers increases whenever two hard particles approach sufficiently close such that their depletion zones overlap and the total depletion zone decreases. Here we provide a historical perspective and highlight modern perspectives of depletion effects.

Asakura (right) and Oosawa (left) in Nagoya.

This historical overview starts with an overview of a number of important applications that were used in technology and medicine before the depletion concept was introduced. For example, clustering of red blood cells due to serum proteins was already detected at the end of the 18th. Furthermore, creaming of colloidal particles to concentrate latex dispersions upon the addition of polysaccharides was first studied in the 1920s. Polysaccharides were also used in the isolation of plant viruses, starting in the 1940s. By now the depletion force is recognized as a versatile tool to direct the phase behaviour of colloidal dispersions. We highlight the effect of depletion interactions to control glass and gel formation in suspensions of colloidal spheres. Finally we illustrate the use of the depletion interaction in the control of self-assembly of colloidal rods as a pathway towards the engineering of new materials.