The Lecture Contains:

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Van der Waals energy of interaction between curved bodies

Below are presented some results on the van der Waals interaction energies for macroscopic bodies in various geometries1. The mathematical analysis is involved, so only final results are shown:

Spherical particles

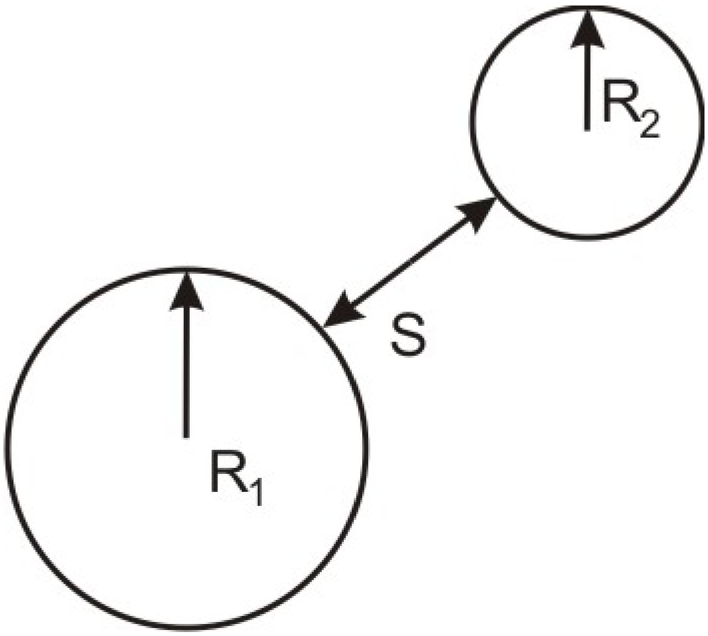

Fig. 8.15:

For two spheres of radii R_1 and R_2 separated by a closest separation distance s (see Figure 8.15), the interaction energy can be written as

$$\emptyset = energy$$

$$= -\frac{A_{Effective}}{6}\left[\frac{2R_1R_2}{s^2+2R_1s+2R_2s}+\frac{2R_1R_2}{s^2+2R_1s+2R_2s+4R_1R_2}+\ln\left(\frac{s^2+2R_1s+2R_2s}{s^2+2R_1s+2R_2s+4R_1R_2}\right)\right]$$

$$Vaccum, A_{Effective} \rightarrow A_{12}$$

$$Medium, A_{Effective} \rightarrow A_{132}$$

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Module 6: "Forces in Colloidal Systems"

Lecture 30:

Apart from A, ϕ depends on R_1, R_2 and s. It can be shown using simple algebraic manipulation that these variables can be reduced to a smaller number:

$$\phi = \phi\left(\frac{s}{R_1}, \frac{s}{R_2}, A_{132}\right)$$

This implies that if s/R_1 and s/R_2 are constant for different particle system then ϕ remains constant.

In real systems, whether or not this energy of interaction is sizeable depends on its relative magnitude as compared to the thermal energy per Brownian particle, kT. If $\phi \ll kT$ then particles do not remain bound to each other for long through the action of LW forces

In the limit $R_1, R_2 \gg s$ the expression reduces to a far simpler form:

$$\Rightarrow \emptyset = \frac{-AR_1R_2}{6s\,(R_1 + R_2)}$$

While in the limit $R_1, R_2 \ll s$:

$$\emptyset = -\frac{16AR_1^3R_2^3}{9s^6}$$

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Sphere and half space

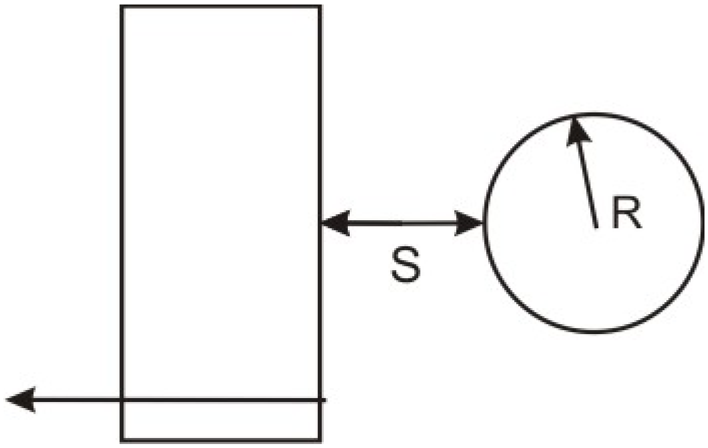

Fig. 8.16:

In the limit $R \gg s$

$$\emptyset = -\frac{AR}{6s}\left[1 + \frac{s}{2R+s} + \cdots\right]$$

In the limit $R \ll s$ $\emptyset \sim -\frac{1}{s^3}$ which is similar to that between a single molecule of one medium with a semi-infinite slab of the other as derived earlier.

Module 6: "Forces in Colloidal Systems"

Lecture 30:

Parallel cylinders

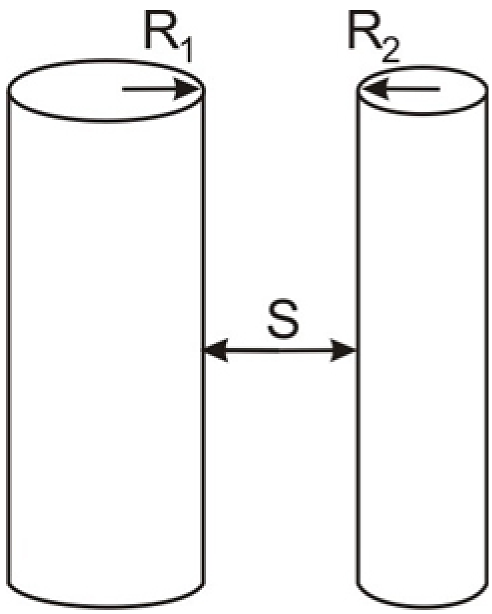

Fig. 8.17:

In the limit $R_1, R_2 \gg s$:

$$V = -\left[\frac{R_1 R_2}{R_1 + R_2}\right]^{0.5} \frac{A}{12\sqrt{2s}^{1.5}}$$

where V is the interaction energy potential per unit length of the cylinders

In the limit $R_1, R_2 \ll s$:

$$V \sim -\frac{Length}{s^5}$$

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