Features of van der Waals Force

- Sphere Near a Plane
- Cylinder near a Flat Plate
- Interfaces
- Hamaker Constants
- Hamaker Constants for Dissimilar Materials

Generally Attractive
Short Range
Origin in Atomic Dipole
**London-van der Waals Force**

Cylinder Near a Surface

\[ F = \frac{A_{12} \cdot d^{1/2}}{16 z_0^2} \]

Planar Surfaces

\[ F = \frac{A_{132}}{6 \pi z_0^3} \]

Surface Energy

\[ \phi = \frac{A_{132}}{12 \pi z_0^2} \]

**Hamaker Constants for Dissimilar Materials**

Two Materials

\[ A_{12} = 2 A_{11} A_{22} \]

Three Materials

\[ A_{132} = A_{12} + A_{33} - A_{13} - A_{23} \]

\[ A_{131} = A_{11} + A_{33} - 2 A_{13} = \frac{(A_{11} - A_{33})^2}{A_{11} + A_{33}} - (\sqrt{A_{11}} - \sqrt{A_{33}})^2 \]

**Table of Hamaker Constants**

\[ \frac{A}{10^{-20}} J \]

<table>
<thead>
<tr>
<th>Materials</th>
<th>Vacuum</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polystyrene</td>
<td>7.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Gold</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Silver</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>16.75</td>
<td>4.44</td>
</tr>
<tr>
<td>Copper</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Water</td>
<td>4.0</td>
<td>-</td>
</tr>
</tbody>
</table>
Table of Hamaker Constants

<table>
<thead>
<tr>
<th>Combinations</th>
<th>Water</th>
<th>Polystyrene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Au-Cu</td>
<td>6.41</td>
<td>5.93</td>
</tr>
<tr>
<td>Au-Diamond</td>
<td>6.11</td>
<td>5.45</td>
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<tr>
<td>Au-Si</td>
<td>5.32</td>
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<tr>
<td>Au-Ge</td>
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<td>5.93</td>
</tr>
<tr>
<td>Au-MgO</td>
<td>1.99</td>
<td>1.25</td>
</tr>
</tbody>
</table>

For Equal Sizes

\[ d_1 = d_2 = d \]

\[ r = d + s \]

\[ \Phi = -\frac{A}{6} \left[ \frac{d^2}{2r^2} + \frac{d^2}{2(r^2 - d^2)} + \ln(1 - \frac{d^2}{r^2}) \right] \]

\[ A_{121} = A_{11} + A_{22} - A_{12} \approx \sqrt{(A_{11} - A_{22})} \]

Surface Energy Between Particles

\[ R = \frac{d_1 + d_2}{2} + s \]

Conclusions

- van der Waals force is very large at short distances
- Short range force
- Can be computed for particles, cylinders and plane interfaces