VO Rendering
SS 2010

Unit 4: Advanced Materials

Sources:

Beyond Normal BRDFs

- Some surfaces that cannot be characterized through standard BRDFs:
  - Phosphorescent paint
  - Fluorescent paint
  - Metallic paint
  - Pearlescent paint
  - BSSRDFs

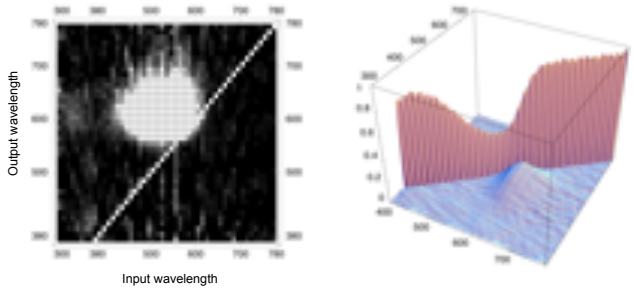
Why challenging?

- Complex structure
  - Fibers (e.g. hair, textiles)
  - Sparkles (e.g. snow, lacquer)
  - Thin layers (e.g. leaves, skin)
- Specialized Material Models

Fluorescence

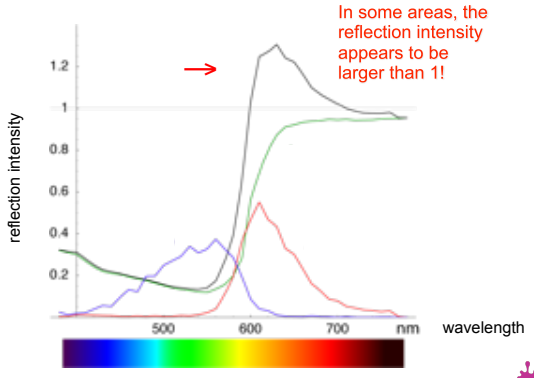
- Re-radiation of incident energy at different wavelengths
- If only re-radiation to lower energy levels is taken into account:
  - Extends reflection spectra to matrices
  - Hard to handle otherwise
- Common effect, but hard to measure - bispectral photometers needed

Re-radiation Example

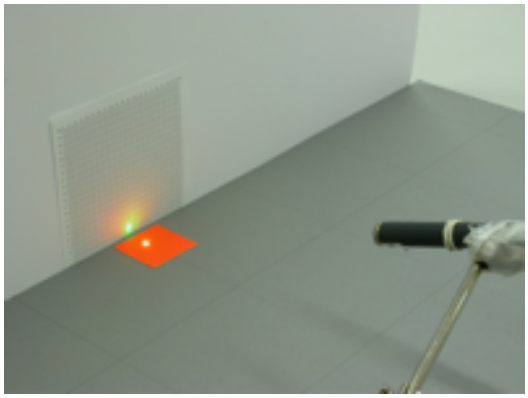


- Fluorescent pigments usually re-radiate light at lower frequency (here: pink 3M Post-It)

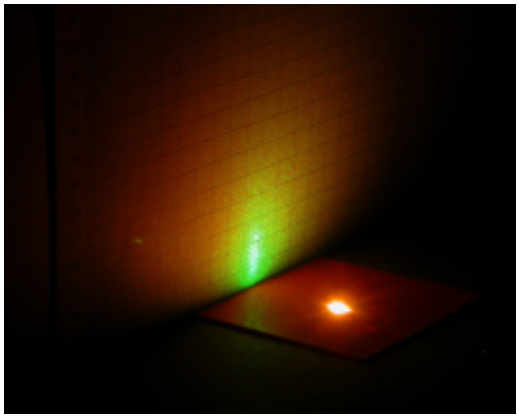
Fluorescence: Energy Transfer



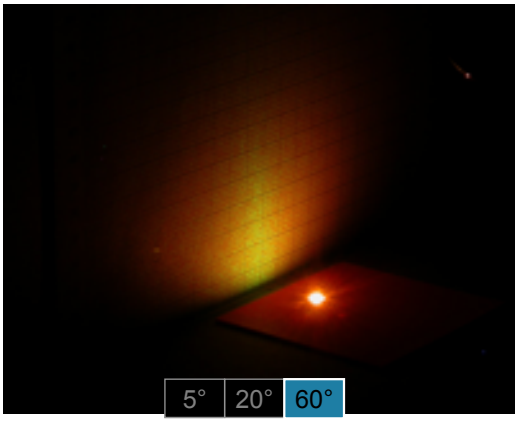
Fluorescent Reflection Experiment



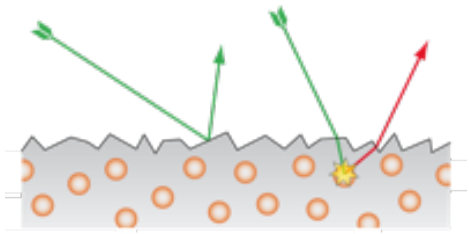
Plain vs. Fluorescent Sample



Fluorescent Sample @ 5°, 20°, 60°



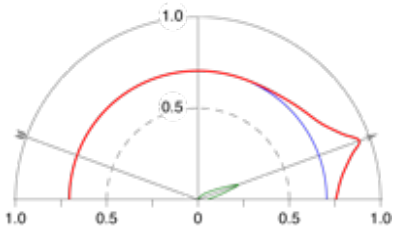
Bi-Coloured Reflection Pattern



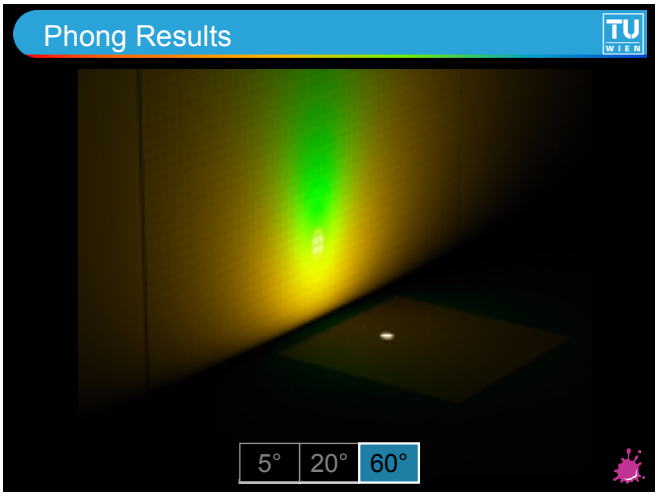
- Rays which are reflected by the substrate retain their colour
- Rays which interact with the colorant molecules undergo wavelength shift

First Approximation: Phong Lobes

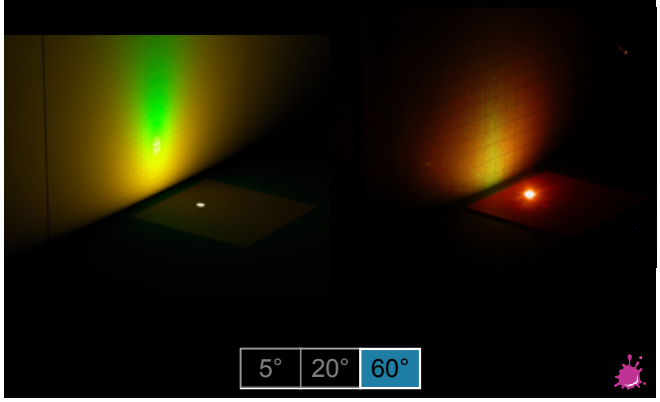
- Superposition of different Phong lobes
- Fixed ratio between lobes
- Large diffuse fluorescent component
- Small specular, non-fluorescent part
- **Advantage**: simple
- **Disadvantage**: results are not very good



Phong Results

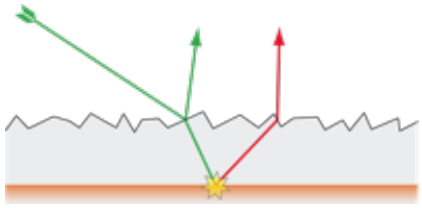


Phong: Comparison to Photos



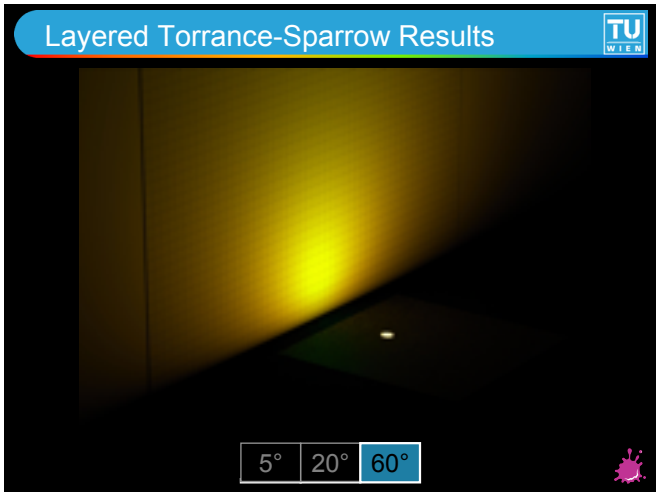
Layered Torrance-Sparrow Model

- Rough dielectric layer over Lambertian fluorescent surface

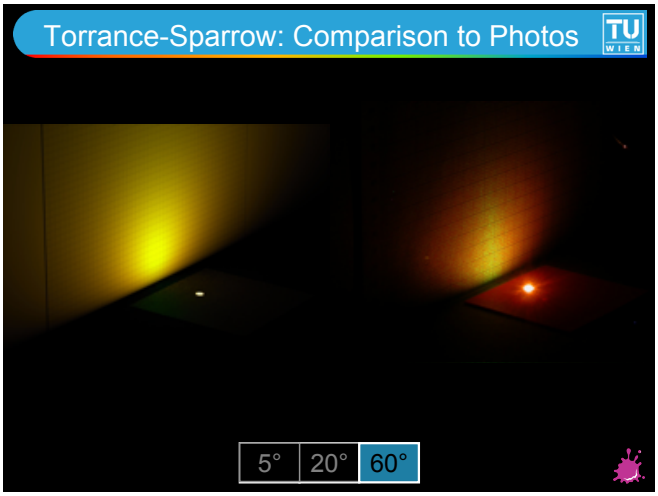


- Blinn microfacet distribution
- No attenuation in the substrate
- Simplified sub-surface scattering - re-emission at the point of incidence

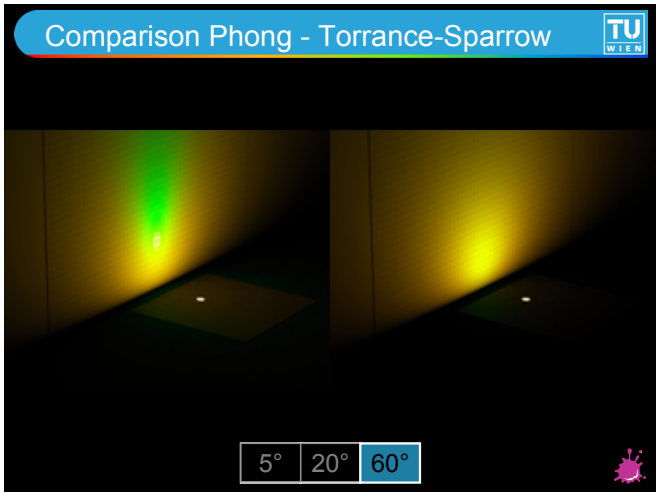
Layered Torrance-Sparrow Results



Torrance-Sparrow: Comparison to Photos

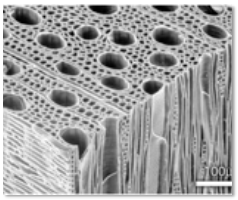


Comparison Phong - Torrance-Sparrow



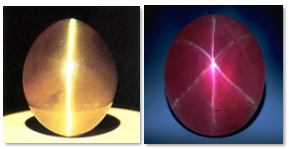
Fibers

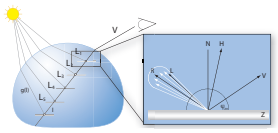
- Many materials are composed of bundles of long thin fiber
- Apearance is modeled by first account for reflection and transmission from individual strands
- E.g. hair, textiles, finished wood



Asterism and Chatoyance

- Reflected light forms luminous band (star) on surface
- Caused by small needle-like inclusions
- Can be simulated with a Phong-like model



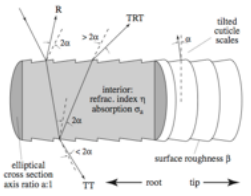


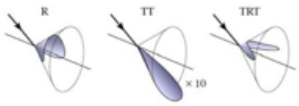
Heterogeneous Gemstones

- Appearance depends on viewing direction
- Often heterogeneou
- Combining several textures

Hair

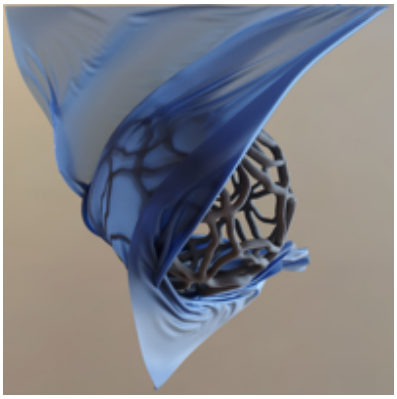
- Not possible to model as a volume
- Strands modelled as cylinders
- Three light paths (R, TT, TRT)
- Gaussian distribution (roughness) times attenuation





Hair

Cloth

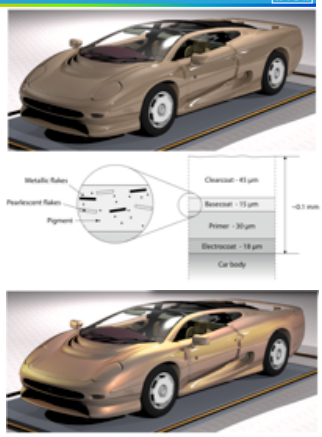


Sparkling Effects

- E.g. snow, metallic paint, gemstones
- Small flecks of a material that has a high specular reflectance.
- Two options
  - Statistically
  - Explicitly

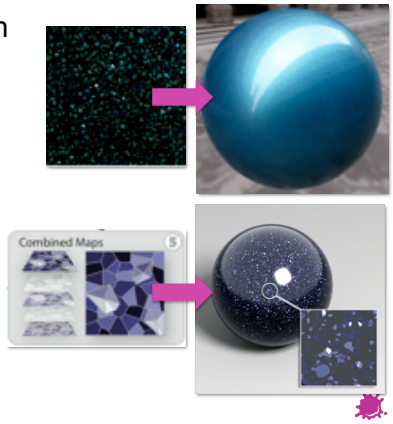
Metallic Paint

- Statistical model
- Substrate: Lambert reflector
- Flakes are modelled with a distribution
- Top: clear coat (Fresnel reflectance)

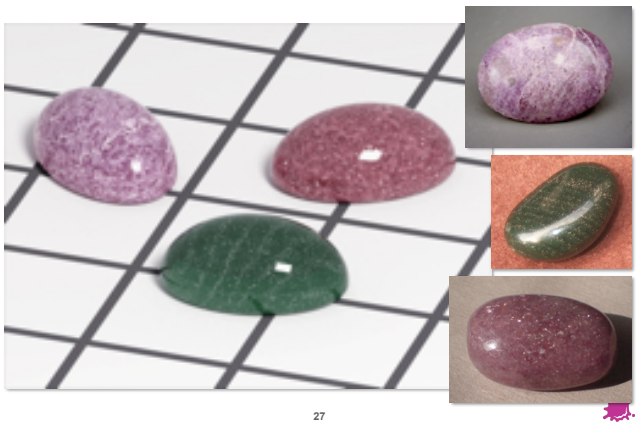


Explicitly modelled flakes

- Bigger flakes can be modelled explicitly
- E.g. BTFs or Voronoi textures



Sparkling in Gemstones

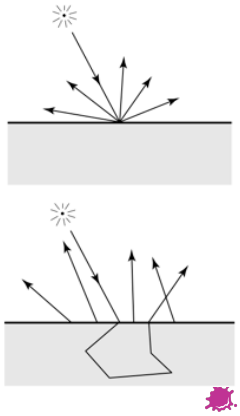


Pearlescent Paint

- Interference effect
- Aluminium or mica flakes coated with thin layers

Subsurface Scattering

- BRDFs: light scatters exactly at the point where it hits the surface
- Subsurface scattering: light enters the material, bounces around and leaves at a different place
- Extension of BRDFs



BSSRDFs

- Bidirectional surface scattering reflectance distribution function
- 8 degrees of freedom (position and direction)
- Monte Carlo evaluation would be very expensive

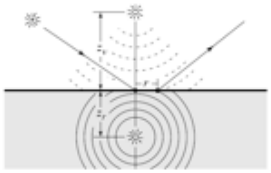
Subsurface Scattering Example

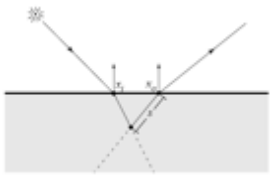
http://graphics.ucsd.edu/~henrik/images/subsurf.html

Subsurface Scattering Animation

Diffusion Approximation

- Dipole model
- Light distribution in highly scattering media becomes isotropic
- Two point sources are placed near the surface
- Complete BSSRDF is sum of diffusion approximation and single scattering term



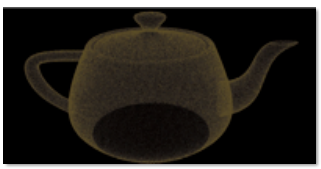


Rendering BSSRDFs

- The BSSRDF model only applies to semi-infinite homogeneous media
- For a practical model we must consider
  - Efficient integration of the BSSRDF
  - Single scattering evaluation for arbitrary geometry
  - Diffusion approximation for arbitrary geometry
  - Texture (spatial variation)

Efficient Rendering

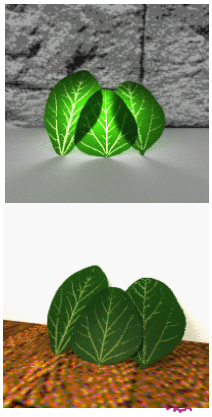
- Two pass approach
- First: Irradiance at set of surface points
- Second: Evaluate BSSRDF



Plant Appearance Example

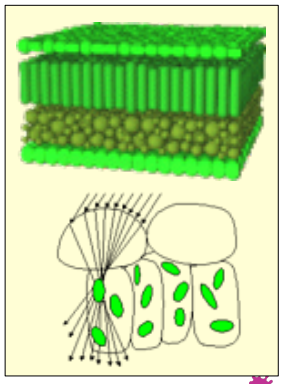
Plant Appearance

- Leaves are the single most important feature of plants
- Reflectance characteristics are far from trivial
- Plain texture-mapping doesn't look realistic
- Multiple subsurface scattering models are needed to explain the observed behaviour
- Measurements are difficult



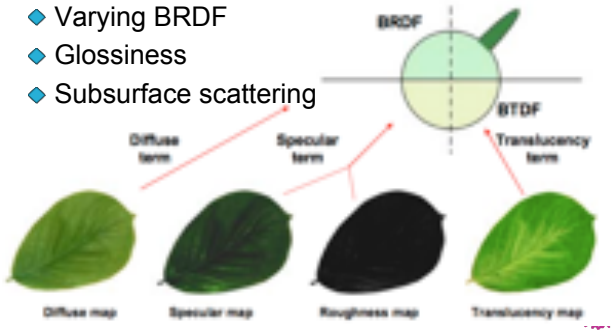
Leaf Structure

- Leaves exhibit a characteristic layered structure of different cell types
- Cells are optimized to get light to photoactive cells ➔ non-obvious characteristics
- Coloured pigments are comparatively rare



Leaf Properties

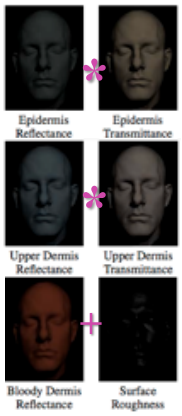
- Properties:
  - Translucency
  - Varying BRDF
  - Glossiness
  - Subsurface scattering



Skin

- Varies in thickness (from 0.1 to more than 0.5 cm)
- Three layers
- Dominated by subsurface scattering (~6% direct reflection, 94% subsurface)

Three-Layer-Model



Heterogeneous Subsurface Scattering

The End

Thank you for your attention!