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Solution 7

General Information

- The exercises may be solved by teams of up to three people.
- The solutions have to be uploaded to the Git repositories assigned to the individual teams.
- **The submission date (for practical and theoretical tasks) is noted on top of each exercise sheet.**
- If you have questions about the exercises write a mail to game-technology@kom.tu-darmstadt.de or use the forum at https://www.fachschaft.informatik.tu-darmstadt.de/forum/viewforum.php?f=557

P7 Practical Task: Physically Based Rendering (5 Points)

Implement the microfacet BRDF specified in the current lecture (Schlick's Fresnel Approximation, the Trowbridge-Reitz Normal Distribution Term, Cook and Torrance's Geometry Factor).

The program that is provided for you allows you to switch between a visualization of the effect of each term and the overall effect of the shader. The keys to use are the following:

- B: Complete BRDF

- F: Schlick`s Fresnel Approximation

- D: Trowbridge-Reitz Normal Distribution Term

- G: Cook and Torrance's Geometry Factor

- T: Toggle (switches whether the two following commands increase or decrease the value)

  - E: Modify roughness

  - D: Modify specularity

https://github.com/TUDGameTechnology/Exercise7.git contains additional code to help you out. You can either copy the code changes manually or just pull them into your own repository using
git pull **https://github.com/TUDGameTechnology/Exercise7.git**

Please remember to push into a branch called "exercise7".

You can find the solution for the practical task at **https://github.com/TUDGameTechnology/Solution7.git**.


T7 Theoretical Tasks (5 Points)

T7.1 Staring at the sun (2 Points)

The sun is described as a directional light in the lecture - a light that emits light rays which all face in the same direction. Quantify this simplification: look up the sizes and distances of the sun and the earth and calculate the maximum angle between light rays from the sun which hit the earth. Outline your calculation path.

The earth has a distance of one astronomical unit, or 149,597,870,700 meters. The radius of the sun is 696,000,000 meters, the radius of the earth is 6,371,000 meters.

From the following diagram, we can see how the maximal angle α can be calculated.
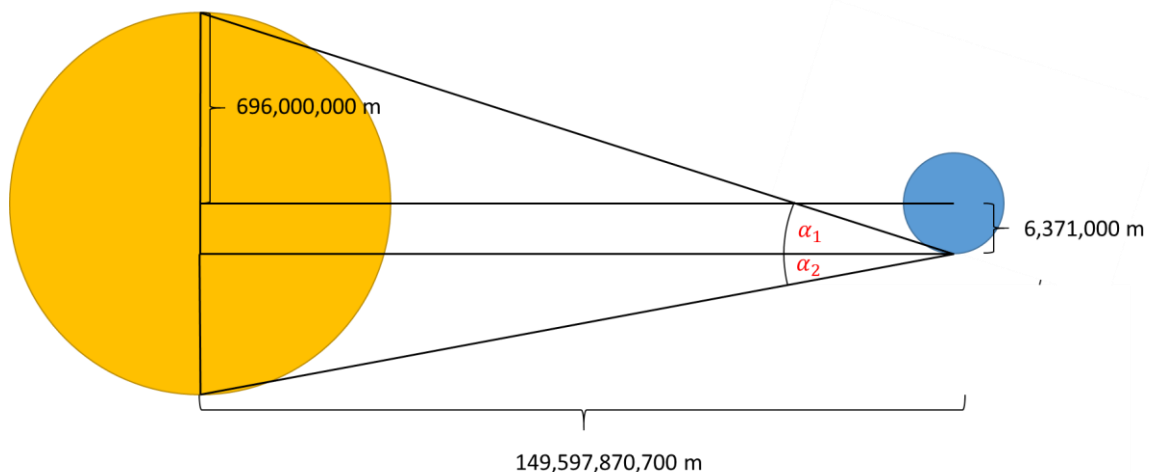
$$\tan(\alpha_1) = \frac{696{,}000{,}000 + 6{,}371{,}000}{149{,}597{,}870{,}700}$$

$$\alpha_1 = 0{,}269°$$

$$\tan(\alpha_2) = \frac{696{,}000{,}000 - 6{,}371{,}000}{149{,}597{,}870{,}700}$$

$$\alpha_2 = 0{,}264°$$

$$\alpha_1 + \alpha_2 = 0{,}269° + 0{,}264° = 0{,}533°$$

T7.2 Scattered (1 Point)

Diffuse reflection is a simplified model, because light that enters a material does not leave at the same position. This is ignored by the BRDF formulation. In realtime applications the BRDF is typically evaluated in the fragment shader. Consider the average distance between light entry and light exit positions for a material. The error is visible when this distance is larger than …?

… one pixel (on the screen). The BRDF we calculate in a fragment shader is already an approximation of the light that is reflected from the surface of one pixel. This includes light that enters the object, travels in the object and then leaves from within the pixel.
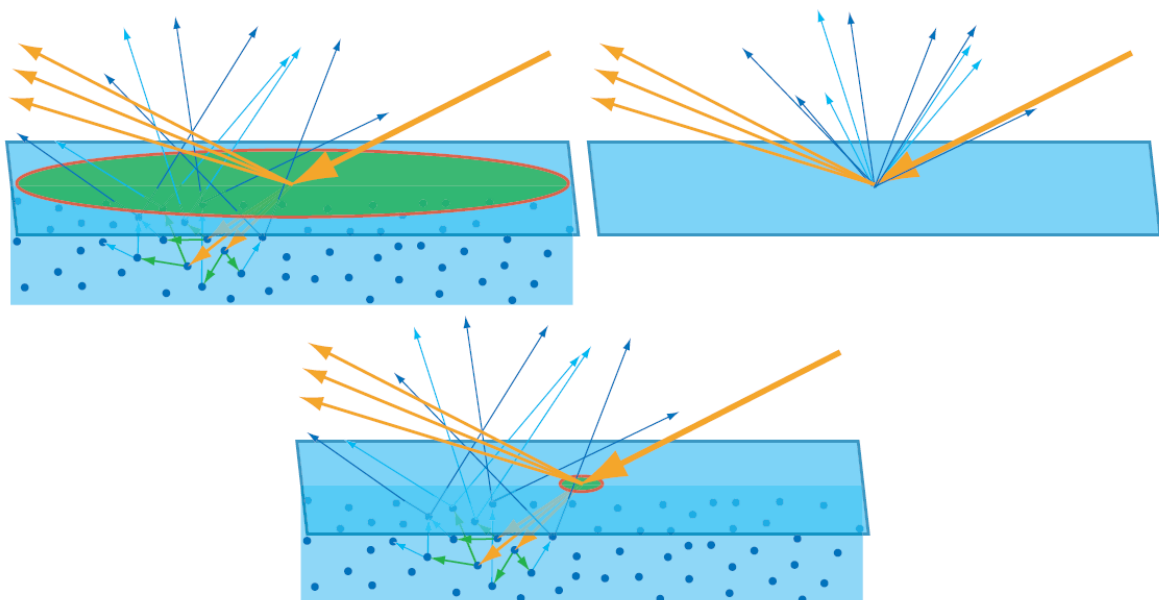
Figure 1: In the upper-left diagram, the footprint of one pixel is larger than the area in which light leaves the material again. In the lower diagram, the footprint of the pixel is too small, therefore, the light that enters outside of the footprint is discarded. (http://renderwonk.com/publications/s2010-shading-course/hoffman/s2010_physically_based_shading_hoffman_a_notes.pdf)

T7.3 Cardboard work

Pick up a light source, a camera and two polarization filters. How do they have to be used to create the pictures in slides 39 and 40 (diffuse and specular cardboard)?

Put a filter in front of the light source and in front of the camera. Take a picture. This picture contains only specular reflections. Take away the filter in front of the camera. Take a picture. Subtract the first picture from the second picture – the result contains only diffuse reflections.