Fluid Lens

Report

Good morning dear jury, teams and spectators. My name is Bondarenko Alexander and I'm representing the team of Lyceum BSU on the problem "Fluid Lens". Here is the problems' definition: **[slide]**

> **Develop a fluid lens system with adjustable focus. Investigate the quality and possible applications of your system.**

Let's start with the definition of an optical lens: ***[slide]***

> ***An optical lens is a transparent material, bounded by 2 curved surfaces.***

We can adjust a fluid lens' focus by adjusting surfaces' curvature. Taking this into account we can give the definition of a fluid optical lens: **[click]**

> **A fluid optical lens is a transparent fluid, bounded by 2 curved surfaces with adjustable curvature.**

Lens is usually formed from a piece of shaped glass or plastic. Nowadays fluid lenses are widely spread, because they are very compact and rather cheap. If high-quality materials are used to produce fluid lenses, they will be equal to usual glass lenses.

While working with the problem, we have set the following aims: **[slide]**

- to examine possible variants of creating fluid lenses;
- to study the quality of an obtained image;
- to examine a possibility of a practical use;
- to use a fluid lens in a basic optical system;
- to prove the equivalence of fluid and glass lenses.

Let's examine possible variants of receiving fluid lenses. We found four main variants: **[slide]**

- a drop on a transparent surface;
- a boundary film between two immiscible fluids;
- a rotating fluid;
- fluid between two elastic films.

Let's examine all variants in details.

1. A drop on a transparent surface. [slide]

It is very easy to see a reversed and reduced image through a rain drop.

So, we take this event as our first model of fluid lens.

A drop works like a collecting lens. For example, it's easy to enlarge a text with the help of it. You can see this on the slide.

What's considering types of lenses, firstly **[slide]** it is a collective lens on a transparent surface. But if we put a little ring on it or a tubule of a rather small diameter, a capillary phenomenon will take place. We will get a divergent lens. It's not easy, but we can change lens' focus by adding or taking away some fluid from the drop in the first case and by changing ring's diameter in the second case.

[Slide] It's interesting to know that a focal power of usual drop is from about 20 to 200 dioptres.

But such lens is very unstable and has a lot of disadvantages such as… So, it is difficult to use it.

2. A boundary film between two immiscible fluids. [slide]

The model of this variant you can see on the slide.

It seems to be that this model is similar to the previous one. Main difference is that this drop floats on another fluid instead of laying on a surface. The idea of this model is to take 2 immiscible fluids and to put a drop of one fluid on another fluid. A focus can be changed by adding or taking away some fluid from the drop.

[slide] Main disadvantages of such variant of lens and the previous one are similar. As you can guess, it's difficult to use it and to work with it too.

3. A rotating fluid. [slide]

A natural method of getting such lens is to rotate a cylindrical container with fluid. In our installation the container with fluid is installed in the chock (colored with red). During rotating the container, centrifugal forces appear and give the fluid a cusp form.

Let's investigate what types of lenses we may get using this technology. **[slide]** It's easy to get to know that we may change curvature of only one surface, so the lens' type will depend on rotating speed.

Well, if we use a flat-bottomed container, we'll get a diverging flat-concave lens. If we make a concave bottom, we'll get a biconcave lens. And if we make a convex bottom and use low rotating speed, we'll get a concave-convex lens with a positive meniscus. Then, if we exceed some speed, increasing it, we'll get a convex-concave lens with a negative meniscus.

Unfortunately we couldn't create such installation, so we investigate two models that you can see on the slide. The difference between these models is in a mount of container with fluid. In our experiments we used flat-bottomed containers.

[Slide] Created such installation we got the following results. There are some photos of the image under the container. As we can see, this is the divergent lens. The image under the container becomes more and more distant.

[Slide] Created the second installation (with torsion suspension), we got divergent lens. In that experiment we used a simple glass. Results of the experiment are presented on the slide.

[Slide] Main disadvantages are…

A main singularity is a cusp form.

4. Fluid between two elastic films. [slide]

This variant of lens we have borrowed from nature. We used a model of a human eye.

[Slide] After some unsuccessful models, we created lens, which you can see on this slide. It can change focus from 15 to 25 dioptres. Some of images, which were received with the help of this lens and the model of this lens you can see on the slide.

The principle of operation of such lens is simple: two soft elastic films are clamped between plates with round holes. Through a small tubule that is placed in space between films, glycerin is being pumped up or out. *There are two main causes to use glycerin: a refraction index of glycerin is higher in compare with refraction index of water and also our films became less transparent in contact with water.*

Due to this technology it's simply to get biconvex and biconcave lenses.

[Slide] And if we put a separator between films, we'll get other types of lenses.

I should say word or two about influence of films on system. Depth of films is nearly 0,8 mm. So, it makes you think that it should be included into calculations. But if we pump lens with air, **[slide]** we'll see that it influence a bit. The distance between building and lens is about 130 m, between lens and obtained image is about 17 cm.

Our team selected this variant of lens. *That's why we have done good calculation for it and compared it with practice results.* **[slide]** График зависимости оптической силы линзы от фокусного расстояния представлен на слайде.

Как видно из графика, расхождение практики с теорией мало и составляет 5-10%.

Developed the lens, we decided to use it in any optical system. We have selected an usual projector. Its scheme you can see on the slide. **[Slide]** If you are interested in I can tell you some words about how it works.

Projector is used to get an enlarged image. It works rather simply: a tape frame or an image on a transparent film is placed near the lens and it should be placed between focus and double focus distance. A lamp or other light source is usually used to illuminate the tape frame. To concentrate a luminous flux on the tape frame a condenser is used. A condenser represents a system of lenses, which collects a luminous flux from a light source on the tape frame. An image of a highlighted tape frame is created on the display with the help of lens.

An image sharpness is set with the lens. That's why we decided to replace a usual lens with a fluid lens. **[Slide]** There is a photo of our projector on the slide.

[Slide] On this slide you can see how is the focusing taking place.

As you can see, the quality of image is rather good.

From my point of view it will be better if we create lens using good instrument and good materials. **[Slide]**

Now it's time to make a resume:

- variants of fluid lenses and methods of getting them have been discovered;
- a fluid lens have been used in a usual projector;
- the equivalence of the image produced by a fluid and a glass lens has been proved.

[Slide] Let's make some conclusions:

- fluid lenses are identical to usual glass lenses;
- the quality of image is rather good. It will be better if a high-quality films are used;
- fluid optical systems are identical to glass optical systems.

*Also I want to add that fluid lenses are also being used. For example, it's used in mobile phones. One French firm (Varioptic) specializes in fluid lenses. But there aren't any engines or piston systems in their fluid lens system. They use technology, called electro wetting! A focus is changed by electric potential***.**

[Slide] So, that's all I want to tell you about fluid lenses! Now I'm ready to answer your questions.

Thank you for attention!