aberration is called a secondary spectrum.

[0020] Apochromat refers to correcting chromatic aberration of light of a wavelength of another color in addition to the red and blue wavelengths. Also, apochromat refers to reducing the above-described secondary spectrum. This correction is also called “superachromatization” and is a quadratic functional chromatic aberration correction.

[0021] Usually, in a microscope or the like, an apochromat aims to remove chromatic aberration. On the other hand, the inventors of the present invention have found that the technique of apochromat is applied to an ophthalmic lens according to one aspect of the present invention so as to increase chromatic aberration instead of removing it. Specifically, the inventors of the present invention have come up with a method of defining a partial dispersion ratio relationship that is different from that of the conventional apochromat between the g-line and the F’-line between the above-described plurality of lenses.

[0022] A first aspect of the present invention is

an ophthalmic lens including two lens elements 1 and 2 having powers with different signs,

in which when an Abbe number (e-line reference) of the lens element 1 having a power with a smaller absolute value is ν_{e1}, and an Abbe number (e-line reference) of the other lens element 2 is ν_{e2}, Formula 1 below is satisfied, and

$$\nu_{e1}<\nu_{e2} \quad \text{...(Formula 1)}$$

when a partial dispersion ratio $P'_{gF'1}$ between a g-line and an F’-line in the lens element 1 having the power with the smaller absolute value, and a partial dispersion ratio $P'_{gF'2}$ between a g-line and an F’-line in the other lens element 2 are set, Formula 2 below is satisfied.

$$P'_{gF'1}>P'_{gF'2} \quad \text{...(Formula 2).}$$

[0023] A second aspect of the present invention is the aspect described in the first aspect,

in which when the absolute value of the power of the lens element 1 is D1 and the absolute value of the power of the lens element 2 is D2, Formula 3 below is

The ophthalmic lens according to one aspect of the present invention is a refractive error progression suppressing lens. The specific configuration is as follows.

"An ophthalmic lens including two lens elements 1 and 2 having powers with different signs,

in which when an Abbe number (e-line reference) of the lens element 1 having a power with a smaller absolute value is v_{e1}, and an Abbe number (e-line reference) of the other lens element 2 is v_{e2}, Formula 1 below is satisfied, and

$v_{e1}<v_{e2}$ ...(Formula 1)

when a partial dispersion ratio $P'_{gF'1}$ between a g-line and an F'-line in the lens element 1 having the power with the smaller absolute value, and a partial dispersion ratio $P'_{gF'2}$ between a g-line and an F'-line in the other lens element 2 are set, Formula 2 below is satisfied.

$P'_{gF'1}>P'_{gF'2}$ ...(Formula 2)"

[0038] There is no particular limitation on the mode of the "ophthalmic lens" as long as it functions as a near-sightedness progression suppressing lens. Eyeglass lenses or contact lenses (i.e., lenses worn outside the eyeball) are examples of ophthalmic lenses. Although the ophthalmic lens described in the present specification may include an intraocular lens (a so-called IOL), the intraocular lens may be excluded from the ophthalmic lens. In one aspect of the present invention, an eyeglass lens is illustrated as an example.

[0039] The eyeglass lens has an object-side surface and an eyeball-side surface. The "object-side surface" is a surface located on the object side when eyeglasses including the eyeglass lens are worn by the wearer, and is a so-called outer surface. The "eyeball-side surface" is the opposite, that is, the surface located on the eyeball side when the eyeglasses including the eyeglass lens are worn by the wearer, and is the so-called inner surface. In one aspect of the present invention, the object-side surface is a convex surface, and the eyeball-side surface is a concave surface. That is, the eyeglass lens in one aspect of the present invention is a meniscus lens.

or negative power can be realized with a combination of the object-side surface and the eyeball-side surface and the refractive index. There is also no particular limitation on the material of the lens element, and the material used as the lens base material may also be used thereas. Also, in the upper paragraph, an example in which the lens elements 1 and 2 are joined was given, but the present invention is not limited thereto. For example, the lens elements 1 and 2 may also be arranged via an interlayer film. In that case, the ophthalmic lens may be manufactured in accordance with the content described in Japanese Patent Application Laid-Open Publication No. 2013-160994.

[0047] Note that if the interlayer film is extremely thin, the interlayer film has the approximate interface shape of the lens elements 1 and 2. In that case, the object-side surface and the eyeball-side surface of the interlayer film are almost the same, and positive or negative power is not realized. In terms of numeric values, whether the power provided by the interlayer film is zero or not, the absolute value of the power is at most 0.12 D. In this case, the interlayer film is not included in the lens element.

[0048] In one aspect of the present invention, a case where the lens elements 1 and 2 are joined is illustrated as an example, but one of the lens elements 1 and 2 may also be in the form of a layer. For example, if the lens element 2 is a lens base material, the lens element 1 may also be a film laminated on the lens base material.

[0049] In the eyeglass lens according to one aspect of the present invention, when the Abbe number (e-line reference) of the lens element 1 having a power with a smaller absolute value is ν_{e1}, and the Abbe number (e-line reference) of the other lens element 2 is ν_{e2}, the following Formula 1 is satisfied. The e-line has a wavelength of 546 nm.

$$\nu_{e1} < \nu_{e2} \quad \text{...(Formula 1)}$$

[0050] Then, when a partial dispersion ratio P'_{gF1} between the g-line and the F'-line in the lens element 1 having the power with the smaller absolute value, and a partial dispersion ratio P'_{gF2} between the g-line (wavelength 436 nm) and the F'-

line (wavelength 480 nm) in the other lens element 2 are set, the following Formula 2 is satisfied.

$$P'_{gF'1} > P'_{gF'2} \quad \text{...(Formula 2)}$$

[0051] The partial dispersion ratio is a value obtained by dividing the partial dispersion by the main dispersion, and in the present specification, a value obtained by subtracting the refractive index $n_{C'}$ at the C'-line (wavelength 644 nm) from the refractive index $n_{F'}$ at the F'-line (wavelength 480 nm) is used as the main dispersion. When n_g is the refractive index at the g-line (wavelength 436 nm) and $n_{F'}$is the refractive index at the F'-line (wavelength 480 nm), $P'_{gF'}$ is expressed by the following formula.

$$P'_{gF'} = (n_g - n_{F'})/(n_{F'} - n_{C'}) \quad \text{...(Formula 3)}$$

That is, $P'_{gF'1}$ represents the partial dispersion ratio between the g-line and the F'-line in the lens element 1, and $P'_{gF'2}$ represents the partial dispersion ratio between the g-line and the F'-line in the lens element 2.

[0052] By combining the above-described lens elements 1, 2, Formula 1, and Formula 2, as shown in the plots of Working Examples 1 and 2 shown in later-described FIG. 4, the focus position of a luminous flux with a wavelength on the short wavelength side among a bundle of visible light rays that pass through the eyeglass lens and pass through the pupil moves significantly to the overfocus side compared to Comparative Example 1 (single lens made of crown glass). On the other hand, the focus position of aluminous flux with a wavelength on the long wavelength side does not change much compared to Comparative Example 1 (single lens made of crown glass) and approaches the retina.

[0053] That is, in the case of the eyeglass lens according to one aspect of the present invention, when the refractive error progression suppressing effect is exhibited due to longitudinal chromatic aberration, the number of factors that hinder the suppressing effect is reduced. Furthermore, since the number of factors that hinder the suppressing effect in the longitudinal chromatic aberration itself is reduced, it is not necessary to provide filtering (a so-called wavelength filter) as described in Patent Document 2. As a result, it is also not necessary to

element 1 is D1 and the absolute value of the power of the lens element 2 is D2, Formula 4 below is satisfied.

$$\{D1\times(1+3\times P'_{gF'1})/\nu_{e1}\}>\{D2\times(1+3\times P'_{gF'2})/\nu_{e2}\} \quad ...(\text{Formula } 4)$$

[0060] By satisfying Formula 4, chromatic aberration of blue light having a wavelength of 453 nm (defocusing of the e-line, i.e., light with a wavelength of 546 nm) is increased compared to when the eye is naked. The wavelength of 453 nm is a wavelength at which the sensitivity of S-cone cells exceeds the sensitivity of other cone cells and rod cells, and thereby light on the shorter wavelength side is more likely to be strongly perceived as blue light by the S-cone cells. Accordingly, it is preferable to give an action of focusing light in front of the retina at a short wavelength of 453 nm or less.

[0061] The derivation process of Formula 4 above will be described.

First, Formula 4 relates to the secondary spectrum mentioned in [Solution to the Problem]. That is, Formula 4 is a specific example for increasing longitudinal chromatic aberration, which is the exact opposite of superachromatization such as apochromat, and focusing the light in front of the retina on the short wavelength side (g-line to F'-line).

[0062] The plot of chromatic aberration ΔD, which is a secondary spectrum, is a quadratic function with respect to the reciprocal of the wavelength (set as K). The quadratic function is set as $\Delta D=aK^2+bK+c$. In addition, the following formula is set.

- Condition that provides positive chromatic aberration with blue light (defocusing with respect to the e-line)

$$\{a(1/453)^2+b(1/453)^2+c\}-\{a(1/546)^2+b(1/546)^2+c\}>0 \quad ...(\text{Formula } 5)$$

- Relational expression of chromatic aberration of F'-line and C'-line (primary chromatic aberration)

$$\{a(1/480)^2+b(1/480)^2+c\}-\{a(1/644)^2+b(1/644)^2+c\}>\{(D1/\nu_{e1})-(D2/\nu_{e2})\} \quad ...(\text{Formula } 6)$$

- Relational expression of chromatic aberration (secondary spectrum) of g-line and F'-line

$$\{a(1/453)^2+b(1/453)^2+c\}-\{a(1/480)^2+b(1/480)^2+c\}>\{(D1/v_{e1})\times P'_{gF'1}-(D2/v_{e2})\times P'_{gF'2}\} \quad ...(\text{Formula 7})$$

[0063] When Formula 6 and Formula 7 are substituted into Formula 5, Formula 8 below is obtained.

$$\{(D1/v_{e1})-(D2/v_{e2})\}+3.01\times\{(D1/v_{e1})\times P'_{gF'1}\}-\{(D2/v_{e2})\times P'_{gF'2}\}>0 \quad ...(\text{Formula 8})$$

[0064] The above-described Formula 4 is obtained by rounding down the decimals in Formula 8.

$$\{D1\times(1+3\times P'_{gF'1})/v_{e1}\}>\{D2\times(1+3\times P'_{gF'2})/v_{e2}\} \quad ...(\text{Formula 4})$$

[0065] If the power of the lens element 1 is positive and the power of the lens element 2 is negative, the near-sightedness progression suppressing effect can be obtained. In this case, preferably, the prescription power of the ophthalmic lens is negative, and the ophthalmic lens is a minus lens. This is because people who need the near-sightedness progression suppressing effect are often already near-sighted, and a minus lens can correct this near-sightedness.

[0066] Incidentally, the prescription data of the wearer information is written on a lens bag (a specification sheet in the case of contact lenses). That is, if there is a lens bag, it is possible to specify the lens as an ophthalmic lens based on the prescription data of the wearer information. Also, an ophthalmic lens is usually in a set with a lens bag or a specification sheet. For this reason, the technical idea of the present invention is reflected in an ophthalmic lens to which a lens bag or a specification sheet is attached, and the same applies to a set of a lens bag and an ophthalmic lens.

[0067] If the power of the lens element 1 is negative and the power of the lens element 2 is positive, a far-sightedness progression suppressing effect can be obtained. In this case, preferably, the prescription power of the ophthalmic lens is positive, and the ophthalmic lens is a plus lens. This is because people who need the far-sightedness progression suppressing effect are often already far-sighted, and a plus lens can correct this far-sightedness. The far-sightedness progression suppressing effect will be described in [Modified Examples].

[0068] Hereinafter, a further specific configuration of the eyeglass lens according

n_{e1}: 2.00009

v_{e1}: 16.72

P'_{gF1}: 0.588

D1: 4.1 [D]

Lens element 2: Power is negative

n_{e2}: 1.86560

v_{e2}: 30.23

P'_{gF2}: 0.529

D2: -8.1 [D]

[0097] <Working Example 2>

The lens elements 1 and 2 according to Working Example 2 were set as follows. Note that Working Example 2 is a preferable example that satisfies Formula 4 above.

Lens element 1: Power is positive

n_{e1}: 2.00009

v_{e1}: 16.72

P'_{gF1}: 0.588

D1: 4.8 [D]

Lens element 2: Power is negative

n_{e2}: 1.86560

v_{e2}: 30.23

P'_{gF2}: 0.529

D2: -8.8 [D]

[0098] <Critical significance of preferred example>

The lens elements 1 and 2 related to the critical significance of the preferred example satisfying Formula 3 above were set as follows.

Lens element 1: Power is positive

n_{e1}: 2.00009

v_{e1}: 16.72

P'_{gF1}: 0.588

D1: 5.8 [D]

Lens element 2: Power is negative

n_{e2}: 1.86560

v_{e2}: 30.23

$P'_{gF'2}$: 0.529

D2: -9.8 [D]

[0099] <Review>

As shown in FIG. 4, in Working Examples 1 and 2, a light ray on the short wavelength side (a light ray having a wavelength smaller than 546 nm) was shifted in the direction in which the power is positive, compared to Comparative Example 1. This indicates that the focus position of the luminous flux on the short wavelength side that passes through the eyeglass lens and passes through the pupil moves to the overfocus side.

[0100] On the contrary, the light on the long wavelength side (i.e., the light on the red light side, or light rays having a wavelength greater than 546 nm) was shifted in the direction in which the power is negative. This indicates that when the effect of suppressing the progression of refractive error is exhibited due to longitudinal chromatic aberration, the number of factors that hinder the suppressing effect was reduced.

[0101] In Working Example 2, the effect of moving the luminous flux focus position on the short wavelength side to the front of the retina is greater than that in Working Example 1. At the same time, in Working Example 2, the focus position of the luminous flux on the long wavelength side can be brought closer to the retina than in Working Example 1. If the focus position of the luminous flux on the long wavelength side is on the underfocus side, the near-sightedness progression suppressing effect is hindered. On the other hand, bringing the focus position of the luminous flux on the long wavelength side closer to the retina means reducing this inhibitory factor.

[0102] Regarding the plot of the critical significance of the preferred example, in the plot, the focus position of the luminous flux on the long wavelength side that

passes through the eyeglass lens and passes through the pupil moves to the underfocus side. This plot is a plot obtained in the case where Formula 3 above is made into an equation. Ultimately, it is preferable to adopt a combination of lens elements 1 and 2 such that the plot is arranged between that plot and the plot of Comparative Example 1. That is, it is preferable to satisfy Formula 3 above.

[0103] [Summary]

The following is a summary of the "ophthalmic lens" disclosed in the present disclosure.

A working example of the present disclosure is as follows.

"An ophthalmic lens including two lens elements 1 and 2 having powers with different signs,

in which when an Abbe number (e-line reference) of the lens element 1 having a power with a smaller absolute value is v_{e1}, and an Abbe number (e-line reference) of the other lens element 2 is v_{e2}, Formula 1 below is satisfied, and

$v_{e1}<v_{e2}$ ...(Formula 1)

when a partial dispersion ratio $P'_{gF'1}$ between a g-line and an F'-line in the lens element 1 having the power with the smaller absolute value, and a partial dispersion ratio $P'_{gF'2}$ between a g-line and an F'-line in the other lens element 2 are set, Formula 2 below is satisfied.

$P'_{gF'1}>P'_{gF'2}$ ...(Formula 2)"

CLAIMS

1. An ophthalmic lens including two lens elements 1 and 2 having powers with different signs,

wherein when an Abbe number (e-line reference) of the lens element 1 having a power with a smaller absolute value is v_{e1}, and an Abbe number (e-line reference) of the other lens element 2 is v_{e2}, Formula 1 below is satisfied,

$v_{e1}<v_{e2}$ ...(Formula 1), and

when a partial dispersion ratio $P'_{gF'1}$ between a g-line and an F'-line in the lens element 1 having the power with the smaller absolute value, and a partial dispersion ratio $P'_{gF'2}$ between a g-line and an F'-line in the other lens element 2 are set, Formula 2 below is satisfied,

$P'_{gF'1}>P'_{gF'2}$ ...(Formula 2),

wherein when the absolute value of the power of the lens element 1 is D1 and the absolute value of the power of the lens element 2 is D2, Formula 3 below is satisfied,

$(D1/v_{e1})<(D2/v_{e2})$ ...(Formula 3),

wherein when the absolute value of the power of the lens element 1 is D1 and the absolute value of the power of the lens element 2 is D2, Formula 4 below is satisfied,

$\{D1\times(1+3\times P'_{gF'1})/v_{e1}\}>\{D2\times(1+3\times P'_{gF'2})/v_{e2}\}$ ...(Formula 4).

2. The ophthalmic lens according to claim 1,

wherein the power of the lens element 1 is positive, and the power of the lens element 2 is negative.

3. The ophthalmic lens according to claim 1,

wherein the power of the lens element 1 is negative, and the power of the lens element 2 is positive.

4. The ophthalmic lens according to any one of claims 1 to 3, comprising

a first refractive region having a first refractive power obtained based on a prescription for correcting refractive error of an eye; and

a plurality of second refractive regions that have a refractive power different from the first refractive power, and have a function of focusing on a position outside of a retina of the eye so as to suppress progression of the refractive error of the eye,

wherein the second refractive regions are formed as respective independent regions near a central portion of the ophthalmic lens, and

the first refractive region is formed outside of the regions in which the second refractive regions are formed.

5. The ophthalmic lens according to any one of claims 1 to 4,

wherein the ophthalmic lens is an eyeglass lens.