Polychromatism of all light waves and a new approach to the interpretation of fluorescence mechanisms; Idea of the fluorescent color monitor

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ABSTRACT

In scientific literature it is considered that only white light is polychromatic and that it is composed of countless monochromatic waves. This research on light vision mechanisms in biosystems and on the mechanisms of formation of deficits in color discrimination reveals that not only white light is polychromatic but all light waves are. This hypothesis brings numerous consequences, two of which we want to address in this work:
- what does the measurement of wavelength mean when the radiation is polychromatic;
- the presence of wavelengths shorter or longer than the incident one must not mean Stokes and anti-Stokes emissions but can be interpreted as the selective absorption/reflection mechanism of a compound radiation.
Based on these considerations, the mechanisms of fluorescence are interpreted as:
1. Pseudo-fluorescence formed by the selective absorption/reflection of **consecutive monochromatic components** of polychromatic blue/violet light – **spectral colors** production;
2. Fluorescence formed by the selective reflection of **non-consecutive monochromatic components** of polychromatic blue/violet light – **fluorescent color** production.
This new approach to the interpretation of fluorescence mechanisms is the theoretical starting point for project a fluorescent colors monitor.

Keywords

Wavelength of polychromatic radiations, Stokes and anti-Stokes emissions or the selective absorption/reflection of polychromatic radiations.

1. INTRODUCTION

This research on light vision mechanisms in biosystems and on the mechanisms of formation of deficits in color discrimination [Nie22b] reveals that not only white light is polychromatic but all light waves are. In this work, two consequences of this hypothesis will be analyzed:
- The measurements of the polychromatic wavelength in spectrophotometric analysis should be considered as an average of its monochromatic components;
- The presence of wavelengths shorter or longer than the incident one must not mean Stokes and anti-Stokes emissions but can be interpreted as the selective absorption/reflection mechanism of a compound radiation.
The objective of this article is to mention a new theoretical approach which concerns the composition of light radiation to address the problems concerning the production of color in monitors with an innovative spirit. In particular, a fluorescent monitor could be useful in signage in conditions of excessive sunlight which causes "blinding" of the monitors.

2. STATE OF ART

In scientific literature it is considered that only white light is polychromatic and that it is composed of countless monochromatic waves. Therefore, the emission of a light wave other than the exciting wave considered monochromatic is referred to as fluorescence or phosphorescence. The fluorescence mechanism is defined as follows: “Property of many solid, liquid and gaseous bodies by which, when they are struck by radiation, they re-emit other radiations with a very short delay (less than 10-8 s), the wavelength of which depends of the exciting radiation and by the nature of the substance (...); the emitted radiations can have a frequency equal to that of the incident radiations (we then have f. by resonance), or, as more often happens, a lower frequency, so that the emission lines and bands for f. are shifted towards longer wavelengths with respect to the lines and absorption bands (Stokes law). In the second case it can happen, and this is what happens in some solids, that the excited atom interacts with the surrounding atoms, in emitting for f. for return to the fundamental state, and that the energy of one or more atomic vibrational quanta also contributes to the energy of what is emitted; the frequency of f radiation is then greater, and the wavelength shorter, than that of the absorbed radiation: thus there is an evident exception to Stokes' law (➔ Stokes, sir George Gabriel), and the lines, or bands, corresponding to the aforementioned frequencies take the qualification of anti-Stokes lines (or bands)."[1] [Enc13]

3. POLYCHROMATIC CONTENT OF THE LIGHT WAVES OF THE VISIBLE

3.1. Selection of 4 monochromatic waves of the visible and perception of 3 fundamental colors

In this research work it is hypothesized that the spectrum of white light is composed of aggregations of only 4 monochromatic waves: *magenta UV*[2] 384 nm, cyan 432 nm, yellow 576 nm and *magenta IR* 768 nm.

magenta IR 432 THz 768 nm	yellow 576 THz 576 nm	cyan 768 THz 432 nm	*magenta UV* 864 THz 384 nm

The four bright waves are perceived as three fundamental colors: cyan 432 nm, yellow 576 nm and *magenta UV* 384 nm and *magenta IR* 768 nm: 768 nm being the multiple of 384 nm is perceived as the same color due to the homologation of frequency multiples by the brain. [Nie22b]

3.2. Composition of 5 bi-chromatic waves of the visible and the additive synthesis of the visible radiation

The spectrum of white light is composed of aggregations of only 4 monochromatic waves: *magenta UV* 384 nm, cyan 432 nm, yellow 576 nm and *magenta IR* 768 nm, grouped in 5 **bi-chromatic** waves. The monochromatic waves will be marked with -1/2, to indicate that they form half of the content of the bright waves, of which unit constitutes a bi-chromatic wave.

single bi-chromatic waves
monochromatic contents [nm]

288	384	432	576	768
384	432	576	768	864

3.2.1. Synthesis of 5 single bi-chromatic waves: indigo-1, green-1, orange-1, *porphyry UV*-1, *porphyry IR*-1

Due to the mechanism of additive synthesis these bi-chromatic waves are perceived as: orange (*magenta IR* + yellow), green (yellow + cyan), indigo (cyan + *magenta UV*) and also two *semi-bright* bi-chromatic waves - *porphyry IR* (semi-infrared wave composed of the *magenta IR* 768 nm wave and the colorless infrared wave 864 nm) and *porphyry UV* (semi-ultraviolet wave composed of the *magenta UV* 384 nm wave and the colorless ultraviolet wave 288 nm).

single bi-chromatic waves [nm]
monochromatic contents

288	384	432	576	768
384	432	576	768	864

perception

porphyry UV-1	indigo-1	green-1	orange-1	*porphyry IR-1*

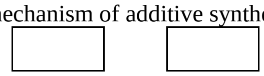
Single bi-chromatic waves will be marked with -1, to indicate that they constitute the fundamental (dual) unit of electromagnetic radiation. The system is called ***PIGOP*** (*Porphyry*, Indigo, Green, Orange, *Porphyry*) and with a different name it wants to differentiate itself from the RGB system.

3.2.2. Synthesis of white 1½

White is synthesized when the quantity of heterogeneous monochromatic waves is equal:
- *magenta UV*-1/2 + cyan-1/2 + yelow-1/2 = *white UV*-1½,
- cyan-1/2 + yelow-1/2 + *magenta IR*-1/2 = *white IR*-1½.

384	
432	432
576	576
	768

perception of white caused by the mechanism of additive synthesis



white UV-1½	*white IR*-1½

But since the spectral radiation are bi-chromatic, white is synthesized as part of radiation composed of at least two bi-chromatic waves. (See paragraph 5).

3.2.3. Synthesis of 7 double bi-chromatic waves: purple-2, cyan + white (cyan-2), yellow + white (yellow-2), red-2, magenta + white (magenta-2), *white UV-2, white IR-2;* Distinction between spectral and non-spectral colors

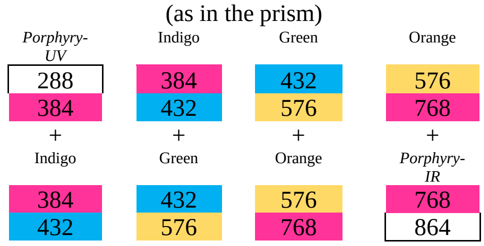
Synthesis between two consecutive bi-chromatic waves (as in the prism) form: purple-2, cyan-½+ white-1½, yellow-½+white-1½ and red-2. In this research the aggregations of consecutive monochromatic and consecutive bi-chromatic waves will be called spectral colors to distinguish them from the *non-spectral* colors formed by aggregations

[1] Author's translation.

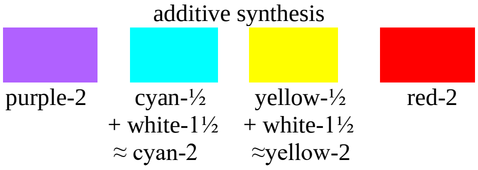
[2] The denomination of the waves that have wavelengths 384 and 768 nm as *magenta UV* or *IR* and *porphyry UV* and *IR* is proposed from the author.

of non-consecutive monochromatic or bi-chromatic waves. We find *spectral* colors for example in stellar radiation and in the decomposition of this radiation. On the other hand, *non-spectral* colors are found, for example, in the superposition of indigo and orange radiations, in reflected radiations in which central monochromatic or bi-chromatic components have been absorbed or in deficits of color vision.
Synthesis between two non-consecutive bi-chromatic waves produces: magenta + white, *white UV*, *white IR*. Double bi-chromatic waves will be marked with -2, to indicate presence of 2 fundamental unit of electromagnetic radiation.

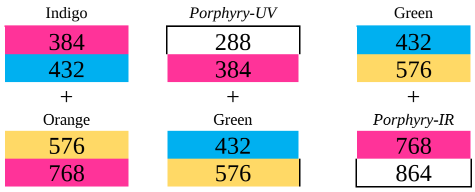
Synthesis between consecutive 2 bi-chromatic waves (as in the prism)



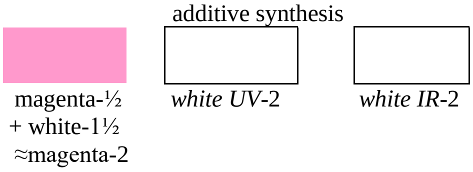
Perception of colors caused by the mechanism of additive synthesis



Synthesis between 2 non-consecutive bi-chromatic waves



Perception of colors caused by the mechanism of additive synthesis

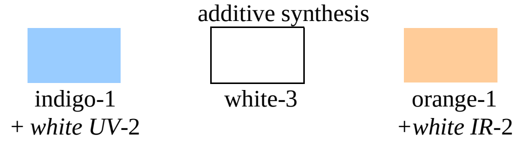


3.2.4. Synthesis of triple bi-chromatic heterogeneous waves

Synthesis of triple bi-chromatic heterogeneous waves (*porphyry IR*-1, orange-1, green-1 and indigo-1, *porphyry UV*-1) form: indigo-1+*white UV*-2, white-3 and orange-1+*white IR*-2.
The aggregations of different 5 bi-chromatic waves together with black form all the existing chromatic shades.

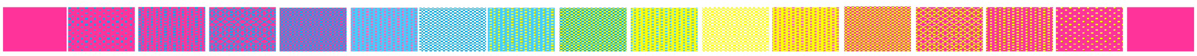
Synthesis between 3 consecutive bi-chromatic waves (interval between stars colors)

Perception of colors caused by the mechanism of additive synthesis

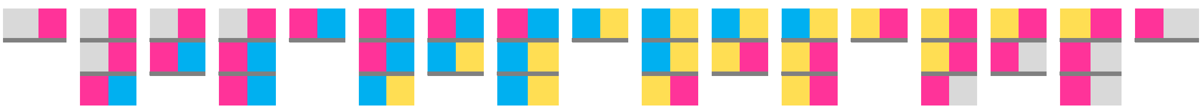


4. POLYCHROMATIC WAVES AND STATISTICAL WAVELENGTH

If we start from the hypothesis of this research that light radiations are polychromatic, the wavelengths should be considered as a statistical average between the monochromatic components of the radiations.
The following table illustrates the aggregations of the bi-chromatic waves: *porphyry IR* and *UV*, orange, green, indigo, their monochromatic contents, the perception of the main colors of the spectrum through the described mechanism of additive synthesis and the average measure of the lengths of the polychromatic waves consisting of the average of the monochromatic components. This calculation is useful for spectral radiation (aggregation of consecutive bi-chromatic waves) and wavelength calculated in this way will be called the statistical wavelength. (Compare wavelength computation from RGB [Ska23a].



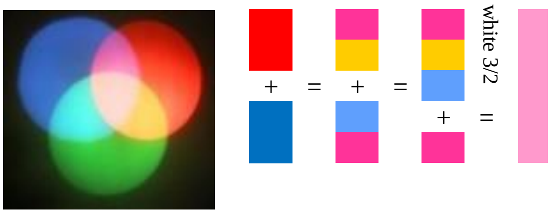
monochromatic contents of polychromatic waves



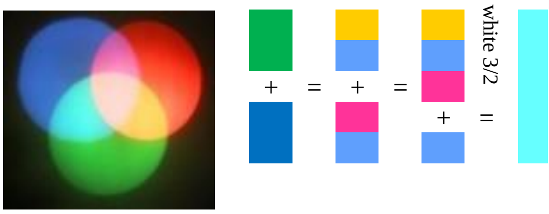
Average measure of the wavelengths of the polychromatic consecutive waves consisting of the average of the monochromatic components: 288, 384, 432, 576, 768, 864 [nm]																
porphyry UV -1	fuchsia -3	violet -2	plum -3	indigo -1	blue -3	cyan -2	turquoise -3	green -1	lemon -3	yellow -2	amber -3	orange -1	pumpkin -3	red -2	wine -3	porphyry IR -1
336	360	372	384	408	440	456	472	504	560	588	616	672	720	744	768	816

5. OVERLAPPING OF THE RED, GREEN AND INDIGO LIGHTS AS EVIDENCE OF THE COMPOSITE NATURE OF THESE RADIATIONS

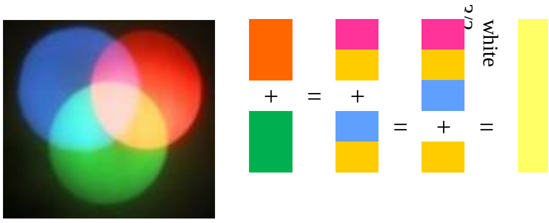
The formation of the magenta, cyan and yellow during the overlapping of the red, green e indigo lights is one of the evidence of the bi-chromatic composition of these radiation provided by the *PIGOP* model, as shown in the following figures:



The formation of magenta clear during the overlap of red and indigo **is possible only if** magenta is one of the components of red and indigo.

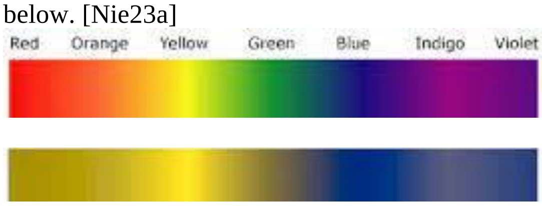


The formation of cyan clear during the overlap of green and indigo **is possible only if** cyan is one of the components of green and indigo.



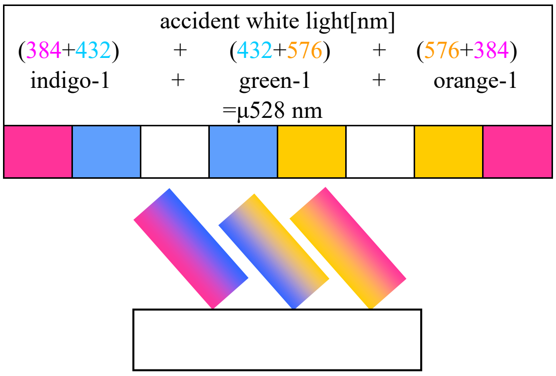
The formation of yellow clear during the overlap of red and green **is possible only if** yellow is one of the components of red and green.

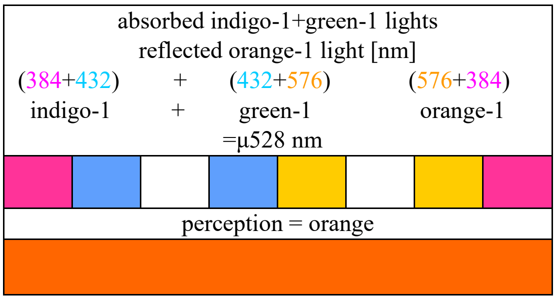
Another evidence of the composite nature of red, green and blue is the confusion between green and red by some types of color blindness in which both colors are perceived as yellow + black. So yellow must be part of both red and green, as show the table below. [Nie23a]

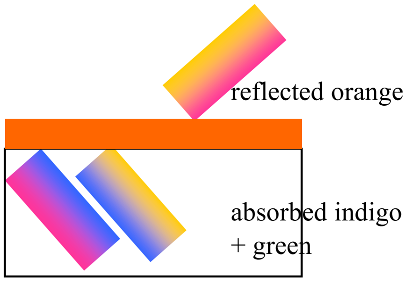


6. ABSORPTION/REFLECTION MECHANISM AND FLUORESCENCE ACCORDING TO THE APPROACH OF THIS RESEARCH

The selective absorption/reflection mechanism refers only to white light since in the literature only white light is considered polychromatic. This mechanism is broadly described as the absorption of a part of the countless monochromatic waves of the incident white light radiation and the reflection of the remaining part, as illustrated in the following table.





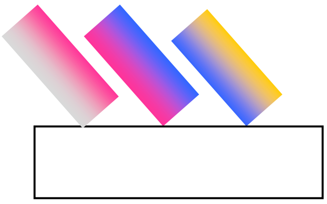


As a consequence of the thesis that all light radiations are polychromatic and that light radiations are aggregations of dual, bi-chromatic waves composed of 4 monochromatic waves: *magenta UV* 384 nm, cyan 432 nm, yellow 576 nm and *magenta IR* 768 nm, two types of selective absorption/reflection mechanisms can be identified:

- *spectral* absorption/reflection when consecutive monochromatic or bi-chromatic reflected waves have the wavelength greater or shorter than the incident one,
- *non spectral* absorption/reflection when non-consecutive monochromatic or bi-chromatic reflected waves have wavelength longer or shorter

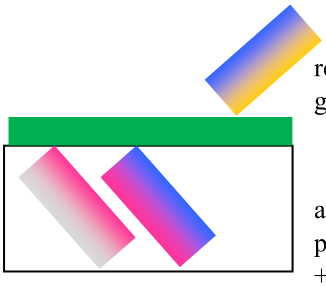
than the incident one; In this case the difference with respect to the *spectral* colors is perceived.
The following tables illustrate both mechanisms with the example of polychromatic blue incident light with a statistical wavelength of 416 nm.

accident polychromatic blue light µ416 nm
(288+384) + (384+432) + (432+576)=
porphyry UV-1 + indigo-1 + green-1=
perception=blue
blue



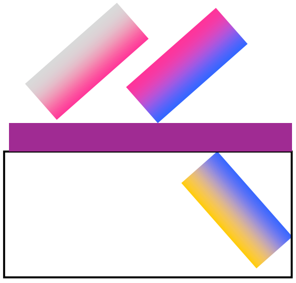
1. *Spectral* absorption/reflection when wavelength of reflected consecutive bi-chromatic waves is **greater than the incident** polychromatic blue **light**.

absorbed *porphyryUV*-1 + indigo-1 lights reflected green-1 light [nm]
(288+384) + (384+432) + (432+576)=
porphyry UV-1 + indigo-1 + green-1=
perception = green



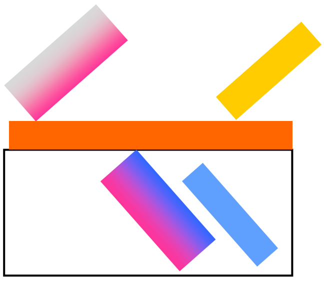
This type of reflection/absorption is called Stokes emission in the literature.
2. *Spectral* absorption/reflection when wavelength of reflected consecutive bi-chromatic waves are **shorter than the incident** polychromatic blue **light**.

absorbed green-1 light [nm] reflected *porphyryUV*-1 + indigo-1 lights
(288+384) + (384+432) + (432+576)=
porphyry UV-1 + indigo-1 + green-1=
perception = porphyry
perception = indigo
perception = porphyry+indigo = violet



This type of reflection/absorption is called anti-Stokes emission in the literature.
3. *Non spectral* absorption/reflection when non-consecutive monochromatic or bi-chromatic reflected waves have wavelength longer or shorter than the incident one; In this case the difference with respect to the *spectral* colors is perceived.

absorbed indigo-1+cyan1/2 lights reflected *porphyry UV*-1+yellow1/2 light [nm]
(288+384) + (384+432) + (432+576)=
porphyry UV-1 + indigo-1 + green-1=
perception = porphyry
perception = yellow1/2
perception = porphyry UV-1 + yellow-1/2 =orange fluorescent



When *spectral* or *non-spectral* reflected radiation:

- replaces *magenta IR* 768 nm with *magenta UV* 384 nm or *Porphyry UV* µ336 nm,

- have the *porphyry UV-1* component or its ultraviolet part of 288 nm,

fluorescent colors are formed, and the perceptual system perceives greater energy content respect the same *spectral* color.

In the following tables there are examples of fluorescent radiation that can be obtained from the reflection of non-consecutive waves and from the replacement of magenta *IR* and/or *porphyry IR* with magenta *UV* and/or *porphyry UV*.

Scheme of the composition of monochromatic and bi-chromatic waves reflected by exciting light blue-3 416 nm formed fluorescent colors

cyan-5/2 fluorescent	orange-3/2 *fluorescent*	yellow UV-1 *fluorescent*	electric blu-3 *spectral*	*white* UV-2 *fluorescent*	red UV-2 *fluorescent*
Monochromatic contents of reflected waves [nm]:					
288	288	288	288	288	288
384	384		384	384	384
			384		384
432			432		
432			432	432	
576	576	576	576	576	576
Statistics wavelengths not useful for spectrographic measures but only to interpret energy content [nm]					
422,4	416	432	416	420	408
Statistic wavelengths of the spectral colors [nm]					
456	672	576		528	744

Scheme of the composition of monochromatic and bi-chromatic contents of spectral e fluorescent orange

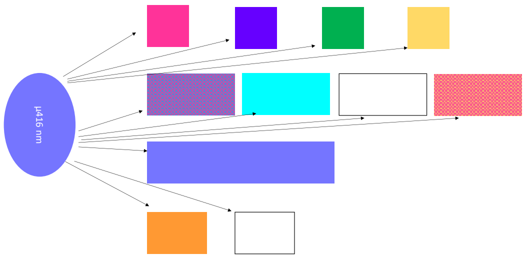
whole spectrum	orange-3/2 *fluorescent*	orange-1 *fluorescent*	orange-3/2 *fluorescent*	*orange-1 spectral*	orange-3/2 *fluorescent*
Monochromatic contents of reflected waves [nm]:					
288	288				288
384	384	384	384		
384					
432					
432					
576	576	576	576		
576				576	576
768				768	768
768					
864			864		
Statistics wavelengths not useful for spectrographic measures but only to interpret and compare energy content [nm]					
	416	432	608	672	736

7. BRIEF MENTION OF VISIBLE FLUORESCENCE INDUCED BY UV RADIATION AS A MULTISPECTRAL INVESTIGATION TECHNIQUE

Visible fluorescence induced by UV radiation is too broad a topic to be addressed in this article. We only want to mention the fact that the radiations used for this technique have a range of around 300-440 nm, therefore according to the theses of this research, which states that light radiations are polychromatic and therefore the wavelengths must be considered an average statistics among the components of a radiation, these radiations between 300-440 nm contain cyan 432 nm, and magenta 384 nm and often also yellow 576 nm. Therefore the "emission" of magenta, violet, blue, white, cyan and even green radiations hues after illumination of an object with for example violet hues could be a simple reflection of its various chromatic content. The table below illustrates icons illuminated with white polychromatic light (a) with violet polychromatic light (b) [Ros12] c. colors that can be reflected from a surface illuminated with a violet light lamp with an ultraviolet component.

a.

b.



c.

8. FLUORESCENT MONITOR IDEA

According to the theoretical approach presented in this research, to obtain fluorescent colors on monitors in the RGB system, the simplest way would be to replace *magenta IR* 768 nm and *porphyry IR* 864/768 nm in red light with *magenta UV* 384 nm and *porphyry UV* 288/ 384 nm as shown in the following table:

Generic composition of bi-chromatic lights in the RGB system

	single bi-chromatic waves [nm] monochromatic contents			
	384	432	576	768
	432	576	768	864
perception				
	indigo-1	green-1	orange-1	*porphyry IR-1*

Composition of bi-chromatic lights in fluorescent monitor.

single bi-chromatic waves [nm] monochromatic contents				
288	384	432	576	
384	432	576	**384**	
perception				
porphyry UV-1	indigo-1	green-1	orange-1	

CONCLUSIONS

The idea, born from studies on the measurement of light in biosystems, that not only white light is polychromatic and that light radiations are dual, i.e. composed of two consecutive monochromatic waves between *magenta IR* 768, yellow 576 nm, cyan 432 nm and *magenta UV* 384 nm, form an alternative perspective on the physics of light, making the theoretical explanation of light phenomena, such as fluorescence, simple and giving applied sciences a new theoretical tool for new technological solutions.

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