

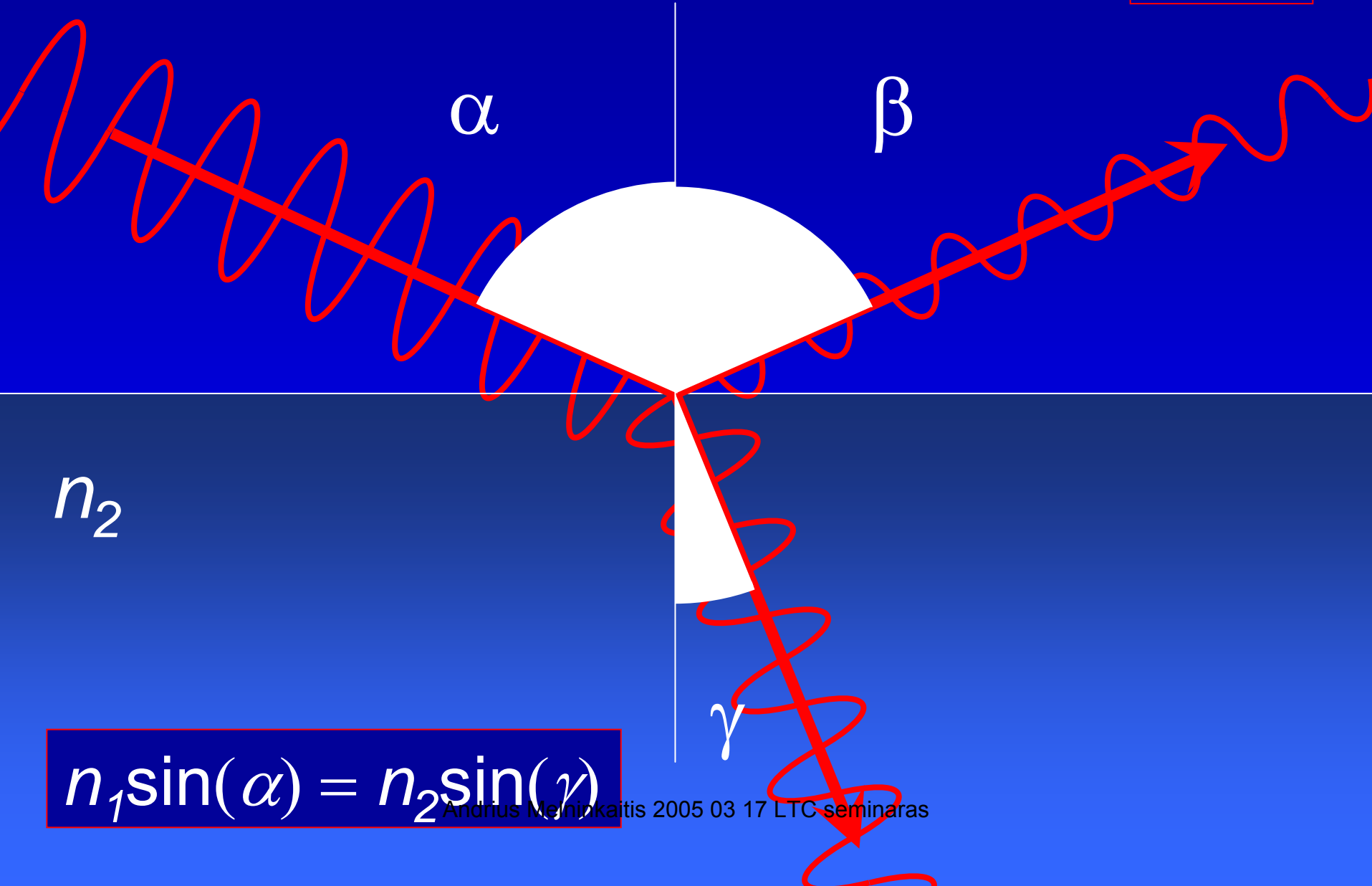
Elipsometrijos principai

Andrius Melninkaitis

Elipsometrija – medžiagos neardantis optinių parametru matavimo metodas, tiriantis atspindėjusios nuo bandinio paviršiaus šviesos poliarizacijos pokytį

n_1

$$\alpha = \beta$$



α

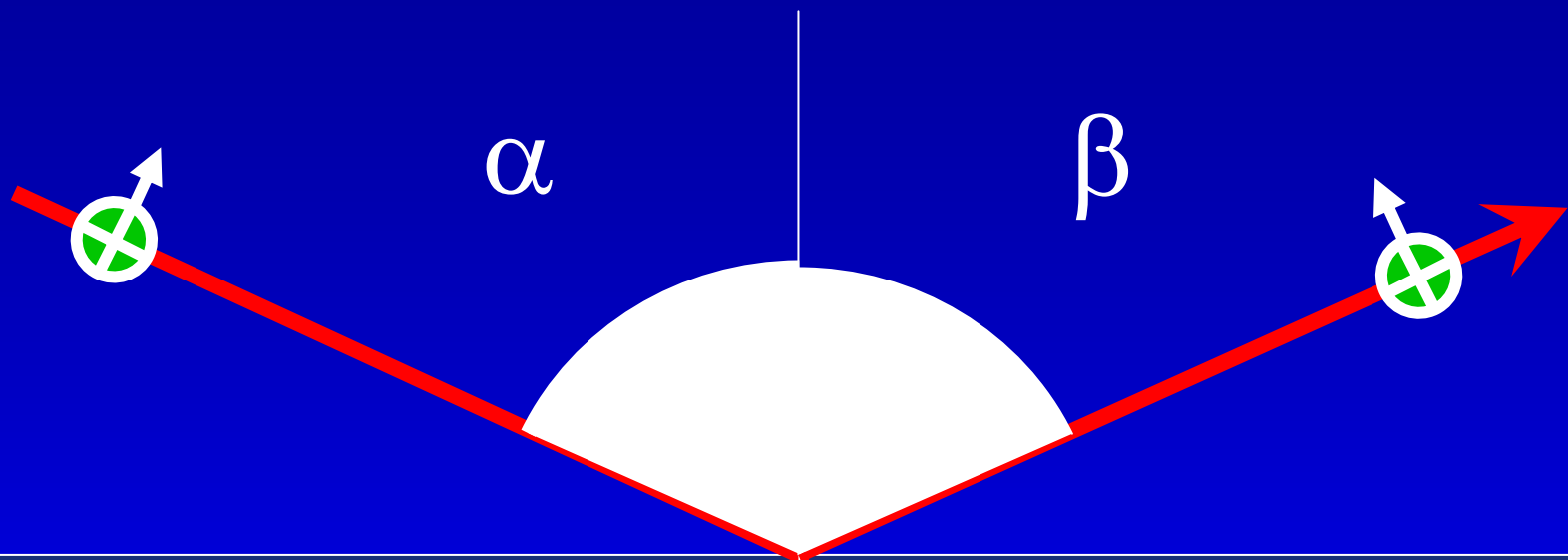
β

n_2

γ

$$n_1 \sin(\alpha) = n_2 \sin(\gamma)$$

n_1



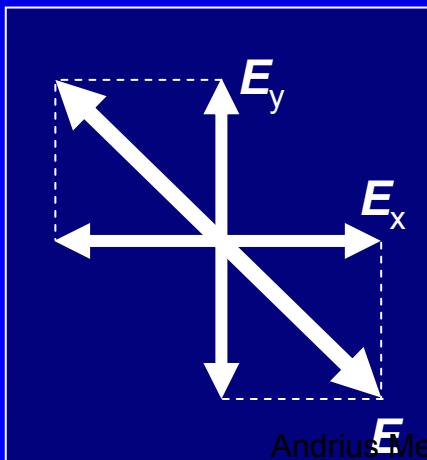
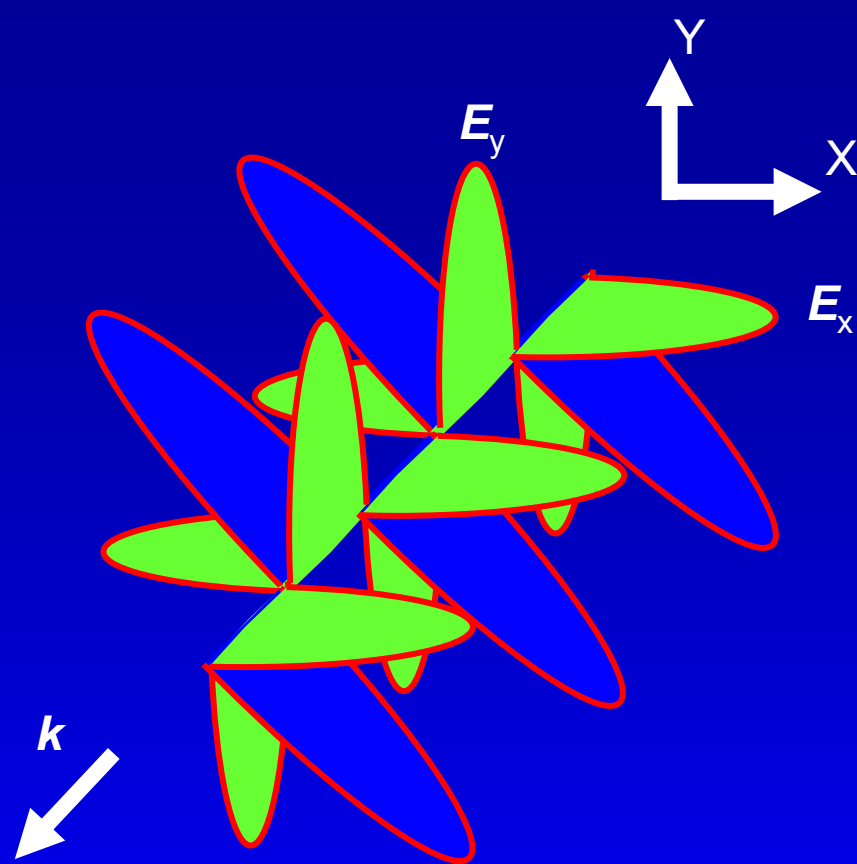
α

β

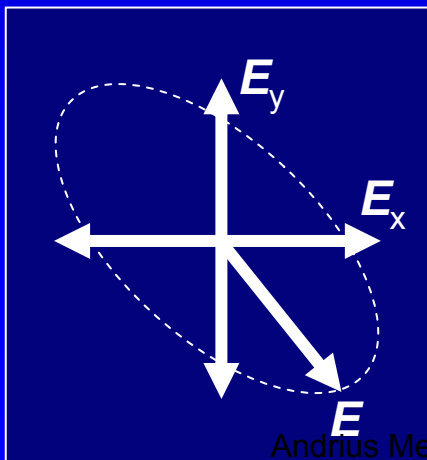
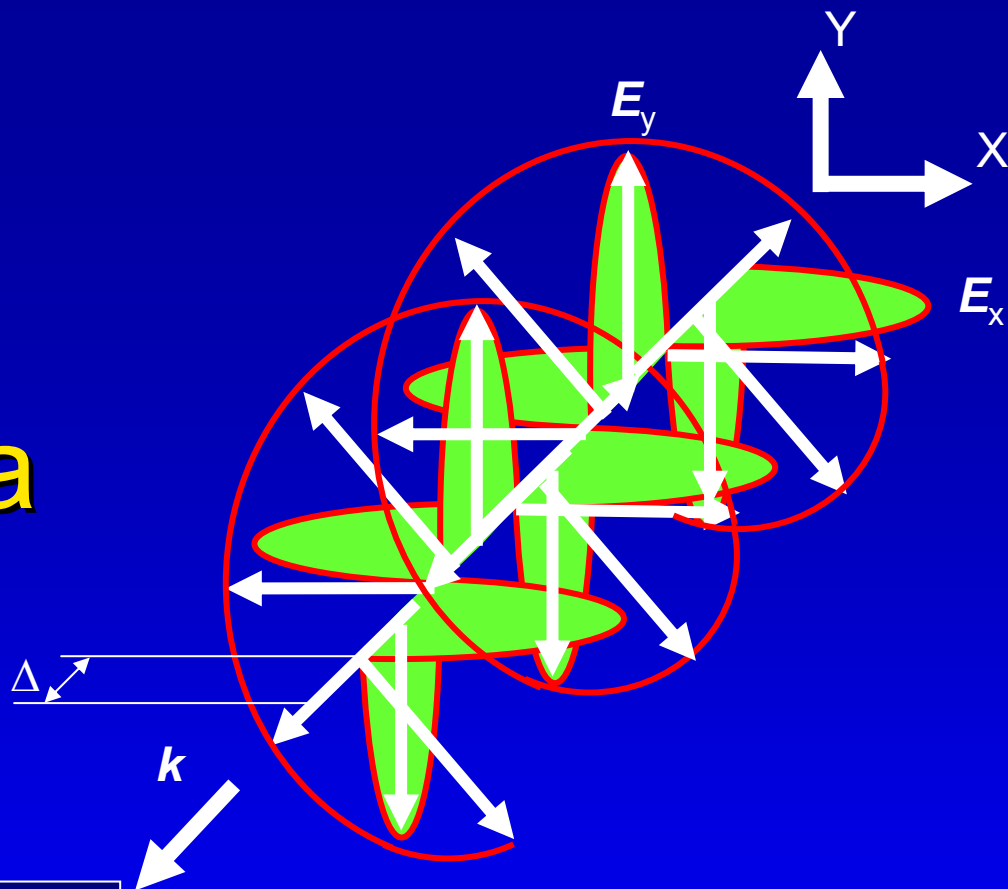
n_2

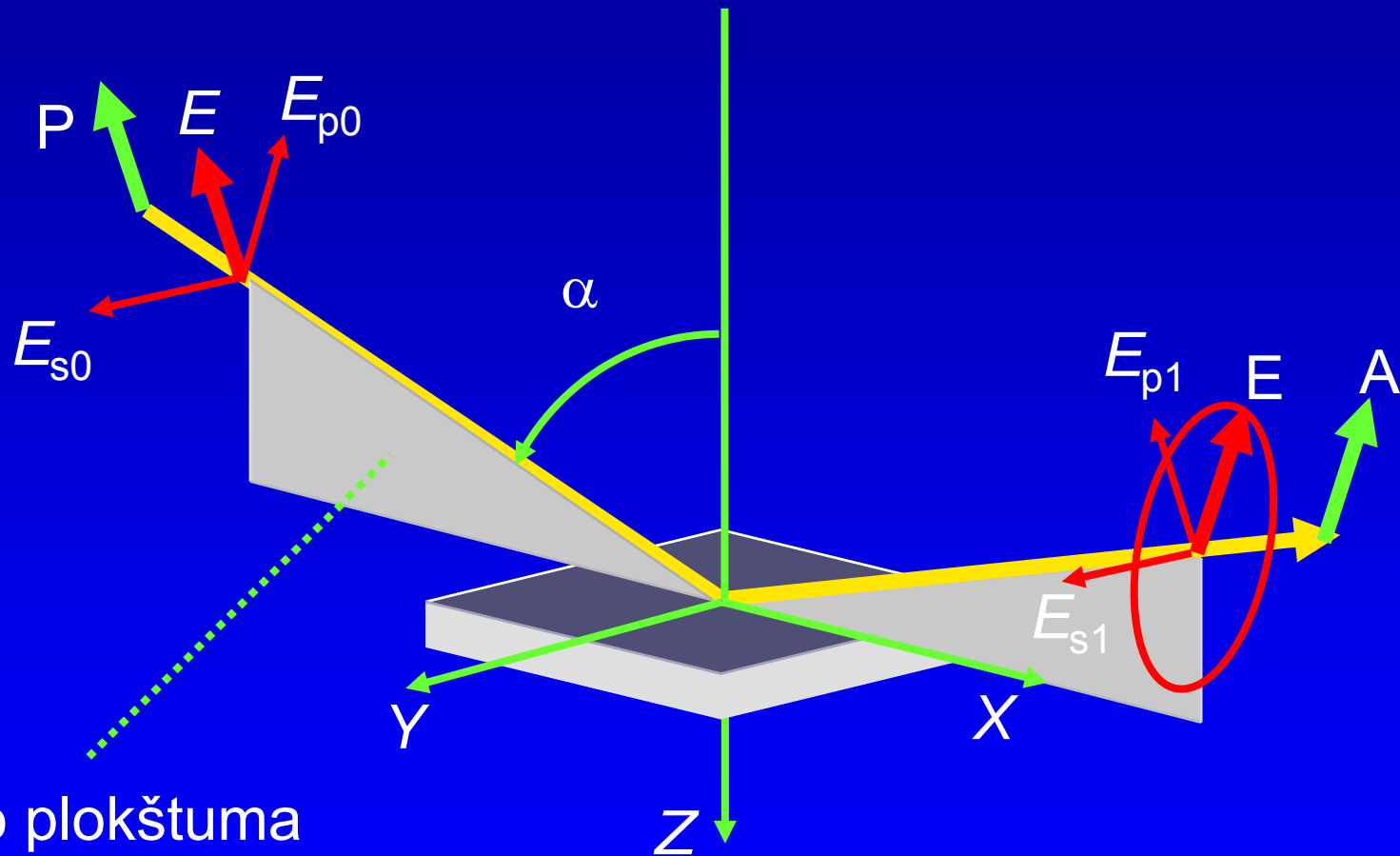
γ

Tiesinė šviesos polarizacija



Elipsinė šviesos polarizacija







Augustin Jean Fresnel

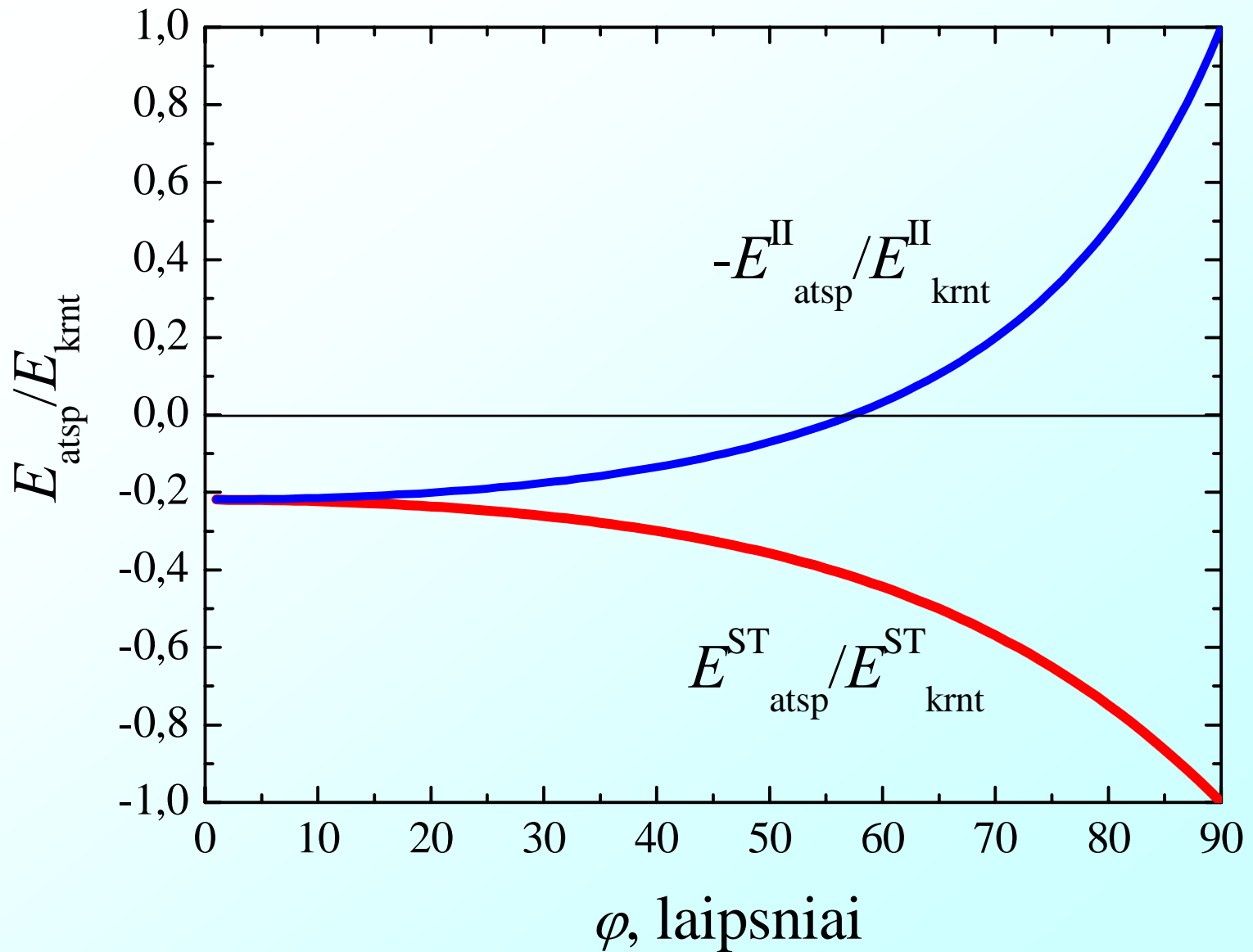
(1788 - 1827)

Frenelio koeficientai

$$r_{01p} = \frac{E_{p1}}{E_{p0}} = |r_p| e^{i\delta_{rp}} = \frac{n_1 \cos(\alpha) - n_2 \cos(\gamma)}{n_1 \cos(\alpha) + n_2 \cos(\gamma)}$$

$$r_{01s} = \frac{E_{s1}}{E_{s0}} = |r_s| e^{i\delta_{rs}} = \frac{n_1 \cos(\gamma) - n_2 \cos(\alpha)}{n_1 \cos(\gamma) + n_2 \cos(\alpha)}$$

α – kritimo kampas, γ – lūžimo kampas

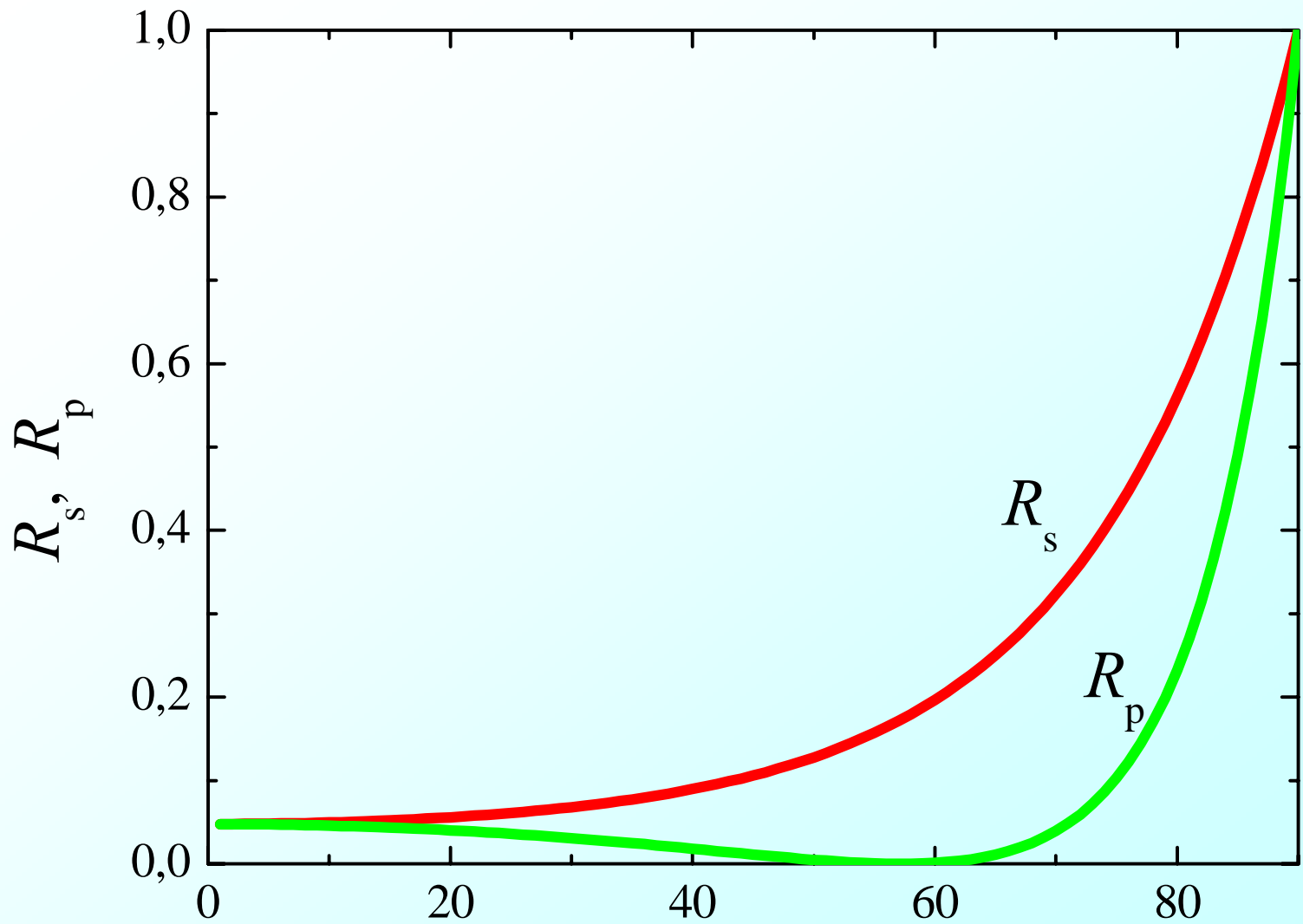


Frenelio atspindžio koeficientai

$$R_p = \left| \frac{E_{p1}}{E_{p0}} \right|^2 = \frac{\operatorname{tg}^2(\alpha - \gamma)}{\operatorname{tg}^2(\alpha + \gamma)}$$

$$R_s = \left| \frac{E_{s1}}{E_{s0}} \right|^2 = \frac{\sin^2(\alpha - \gamma)}{\sin^2(\alpha + \gamma)}$$

α – kritimo kampas, γ – lūžimo kampas



α , laipsniai



Paul Karl Ludwig
Drude

(1863 - 1906)

Elipsometrijos lygtis

$$\operatorname{tg}(\Psi)e^{i\Delta} = \frac{r_p}{r_s}$$

Matuojami dydžiai

$$\Delta = \delta_{r_p} - \delta_{r_s}$$

$$\operatorname{tg}(\Psi) = \frac{|r_p|}{|r_s|}$$

n_1

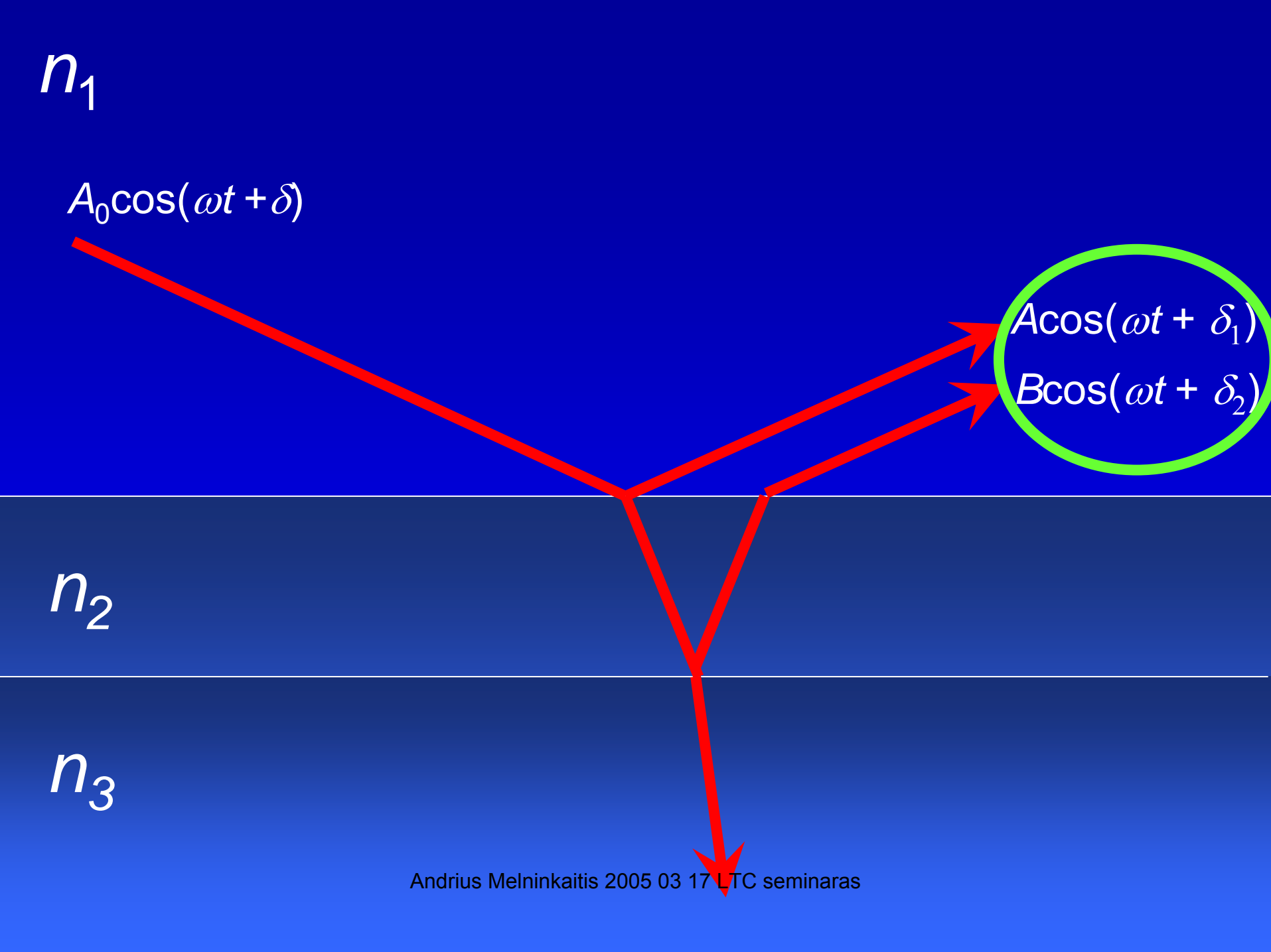
$A_0 \cos(\omega t + \delta)$

$A \cos(\omega t + \delta_1)$

$B \cos(\omega t + \delta_2)$

n_2

n_3



Jei sudėsime harmoninius signalus,
kurių dažnis yra vienodas:

$$A \cos(\omega t + \delta_1) + B \cos(\omega t + \delta_2) = C \cos(\omega t + \delta_3)$$

arba

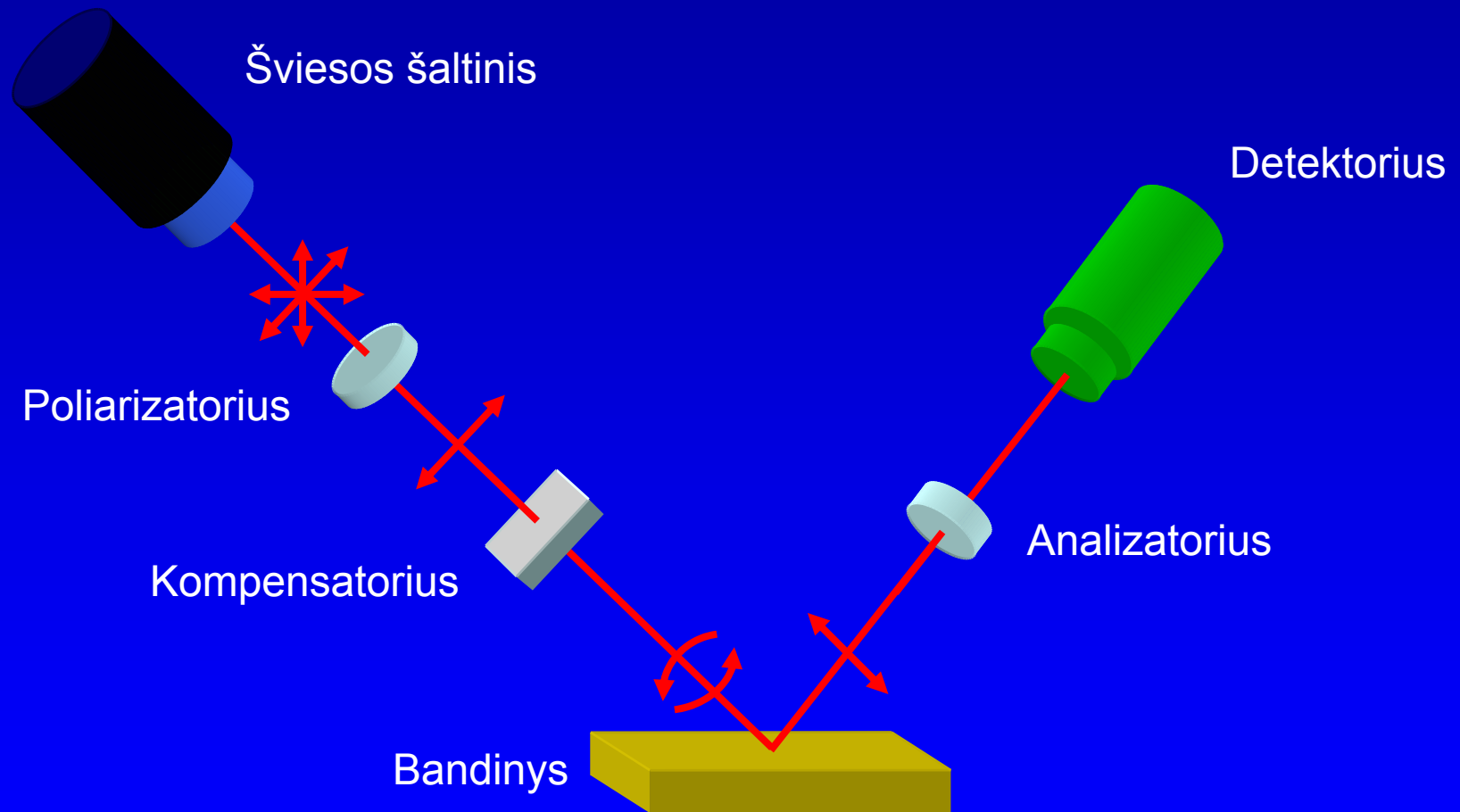
$$A \sin(\omega t + \delta_1) + B \sin(\omega t + \delta_2) = C \sin(\omega t + \delta_3)$$

kur:

$$C = \sqrt{A^2 + 2AB \cos(\delta_1 - \delta_2) + B^2}$$

$$\tan(\delta_3) = \frac{A \sin(\delta_1) + B \sin(\delta_2)}{A \cos(\delta_1) + B \cos(\delta_2)}$$

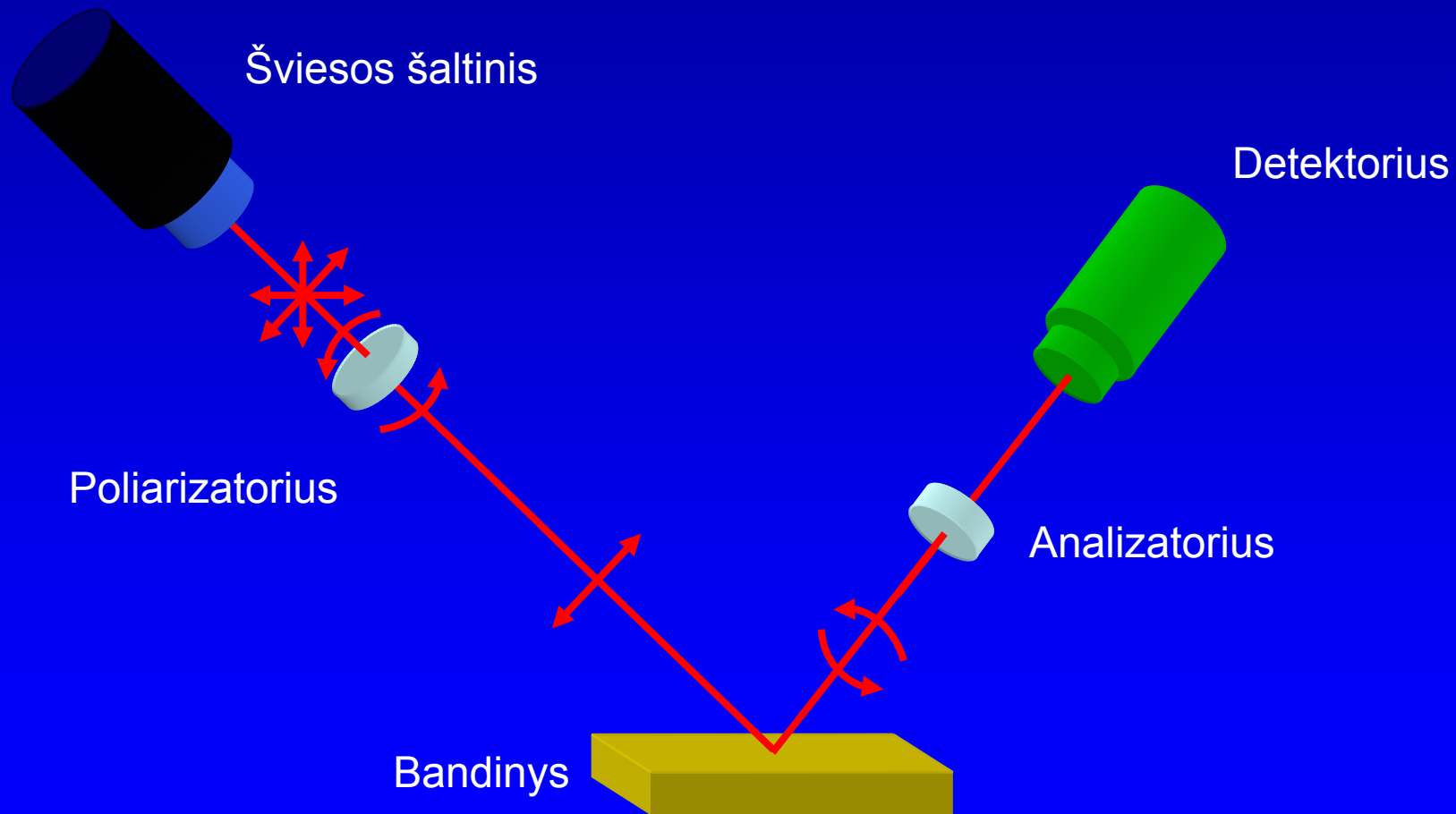
Elipsometro optinė schema



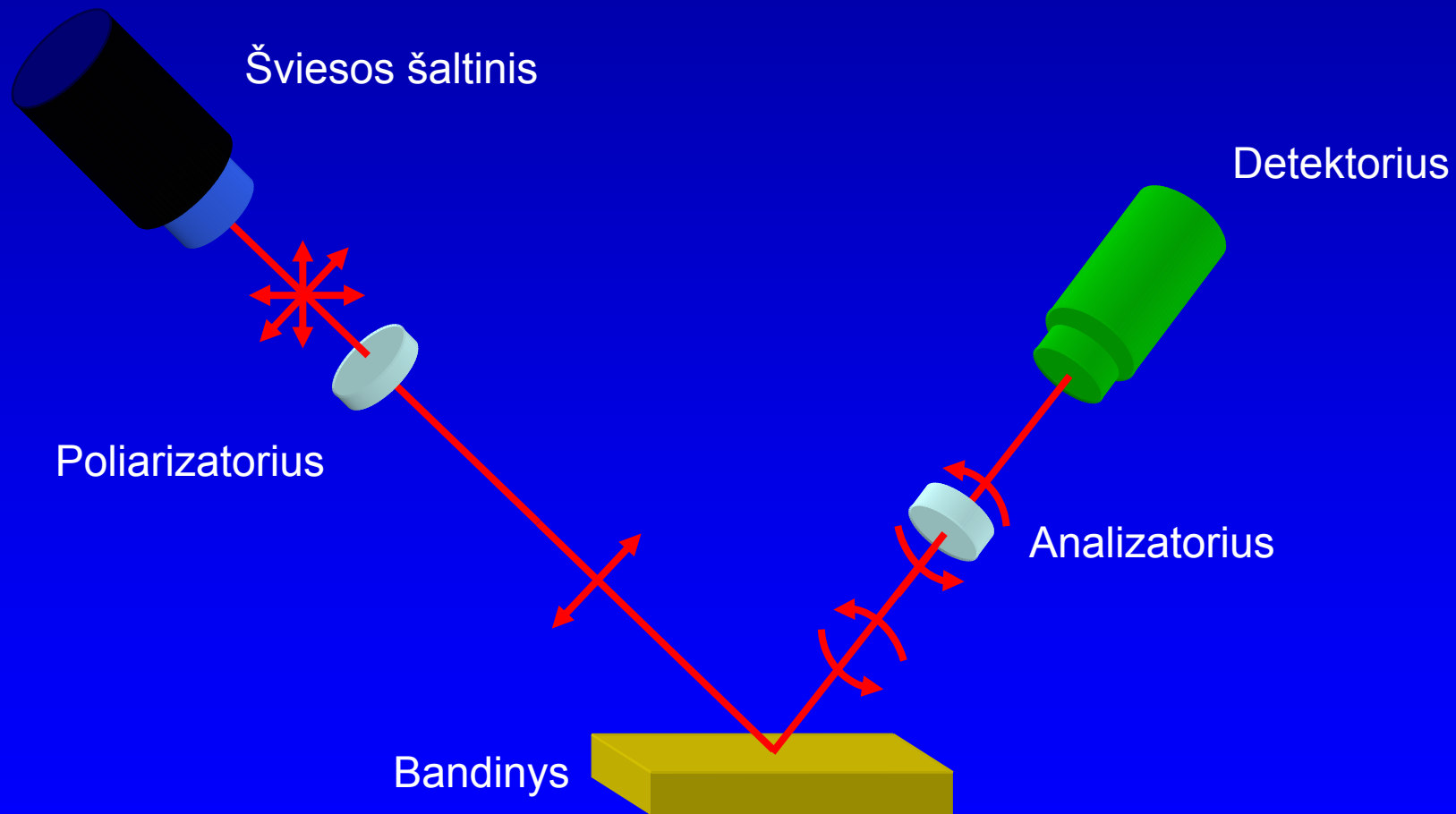
Elipsometrijos rūšys:

- **Kampinė elipsometrija (VAE)**
Variable Angle Ellipsometry
- **Spektroskopinė elipsometrija (SE)**
Spectroscopic Ellipsometry
- **Kampinė - spektroskopinė elipsometrija (VASE)**
Variable Angle Spectroscopic Ellipsometry

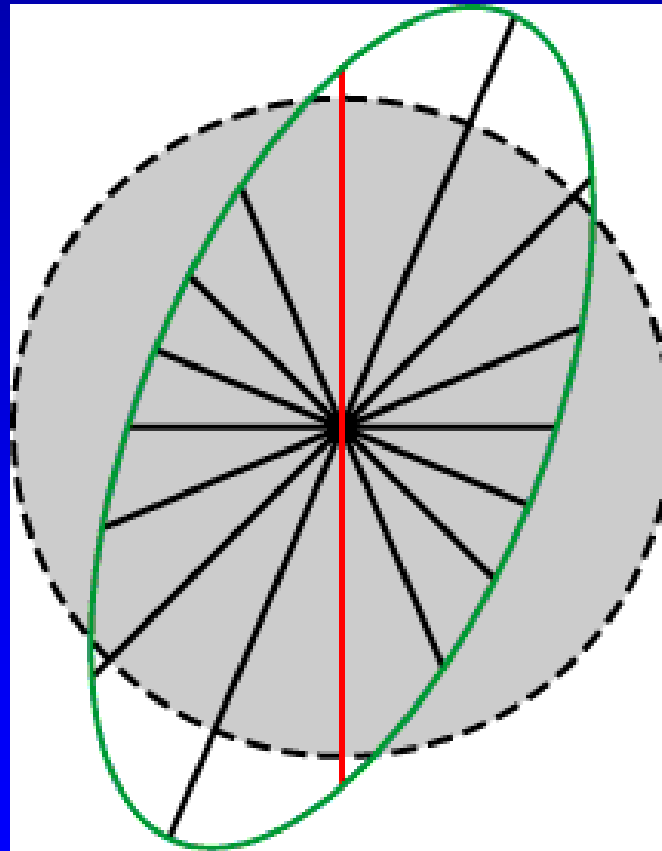
Besisukančių elementų elipsometrija



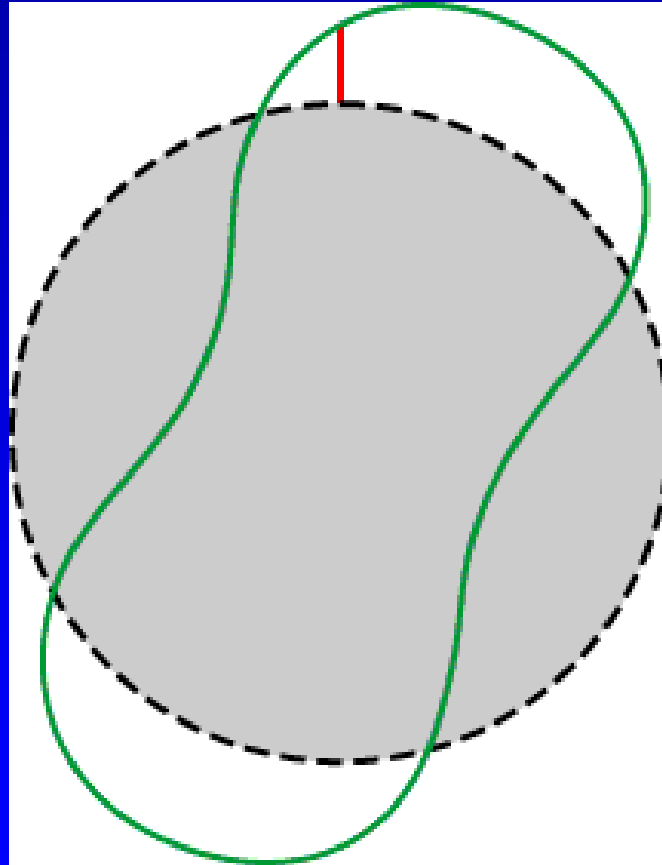
Besisukančių elementų elipsometrija



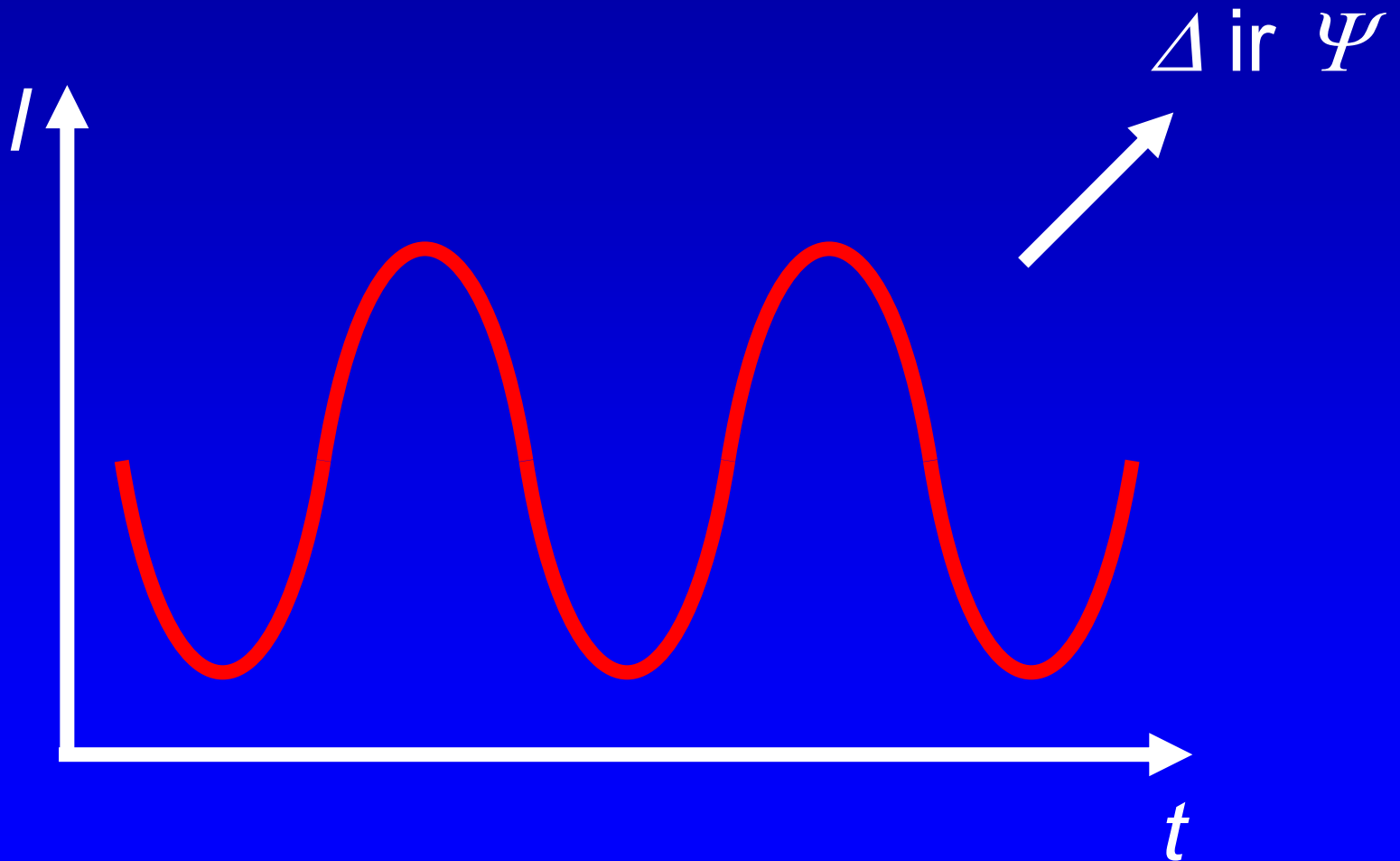
Basisukančių elementų elipsometrija



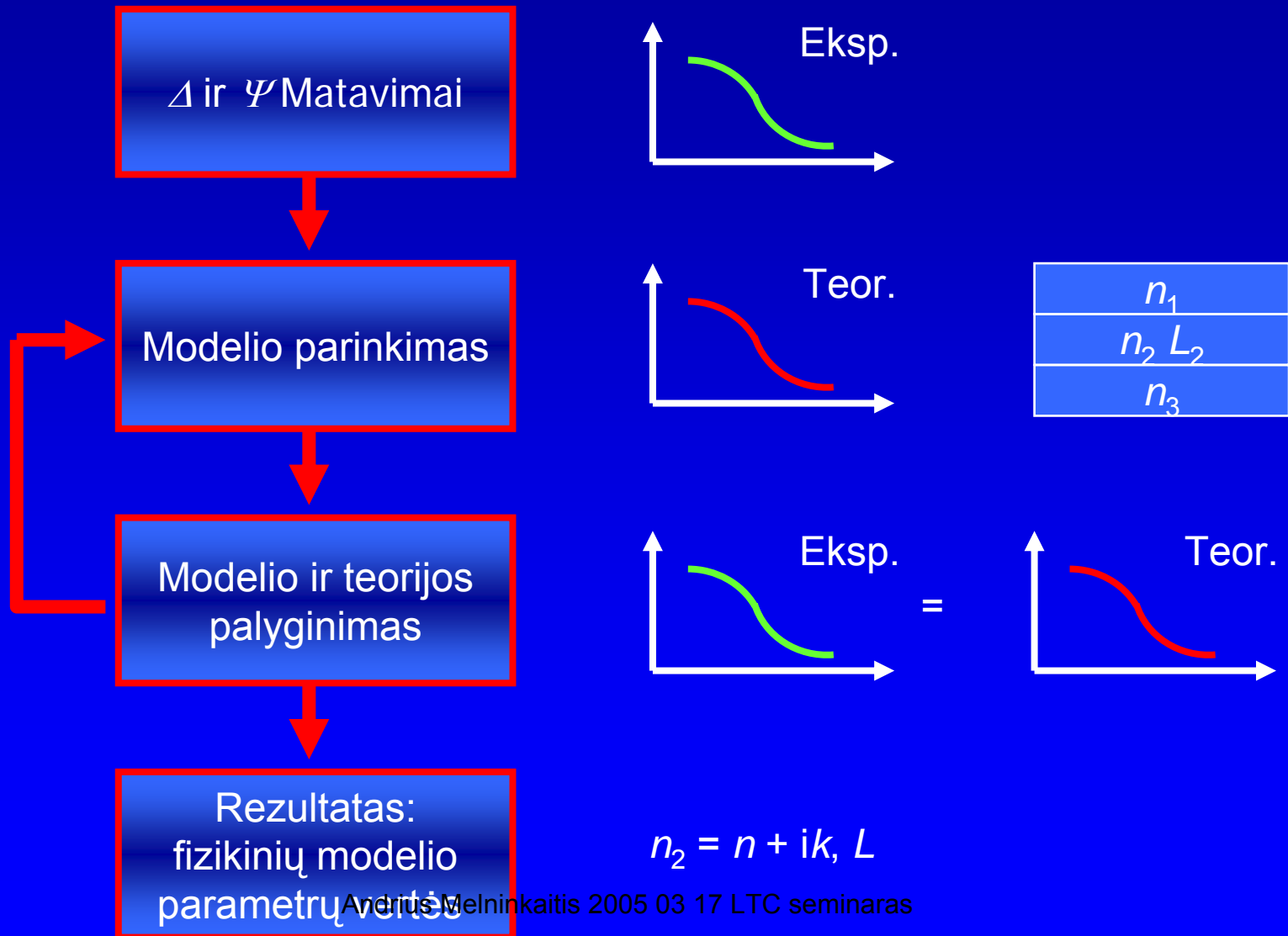
Basisukančių elementų elipsometrija

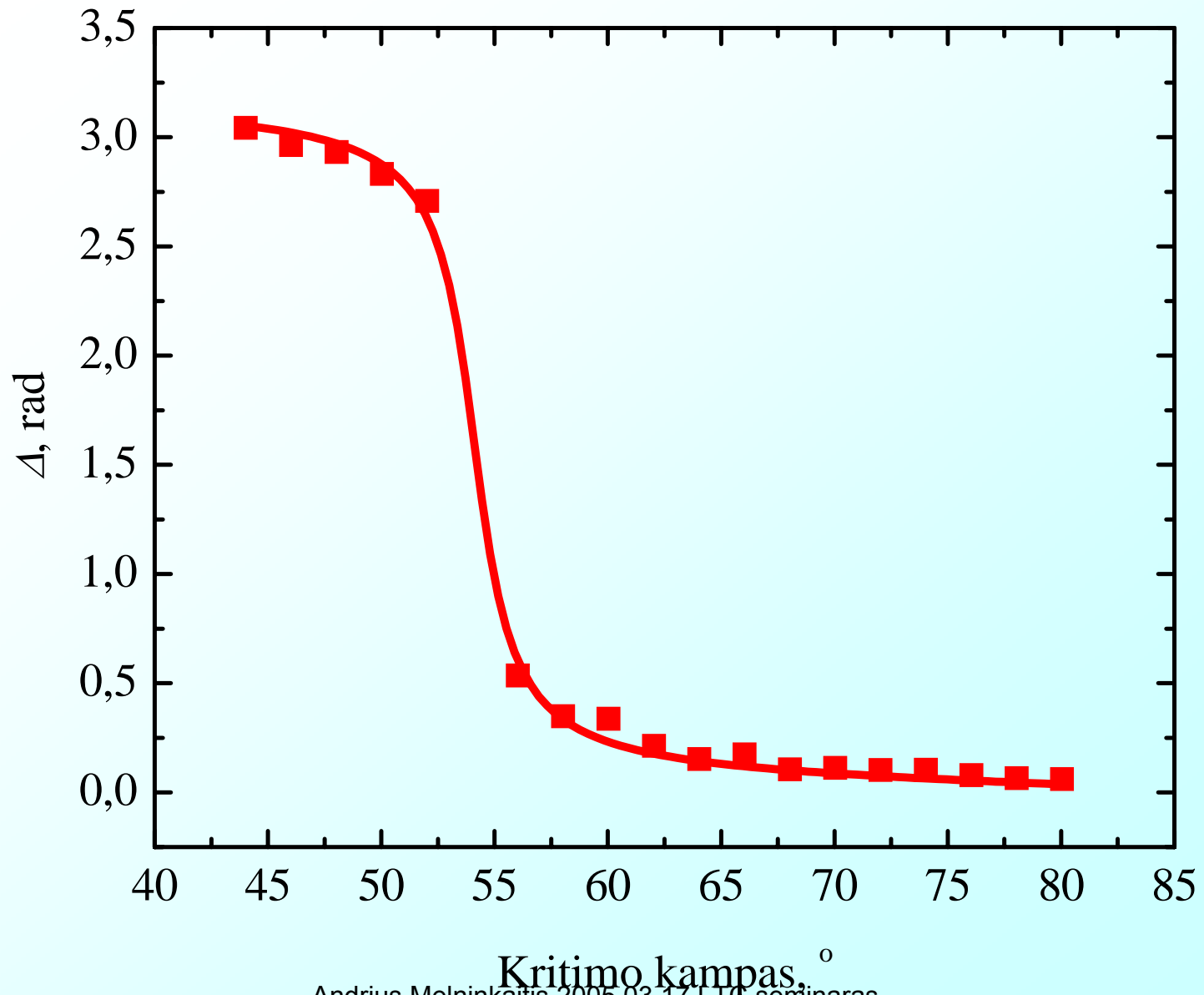


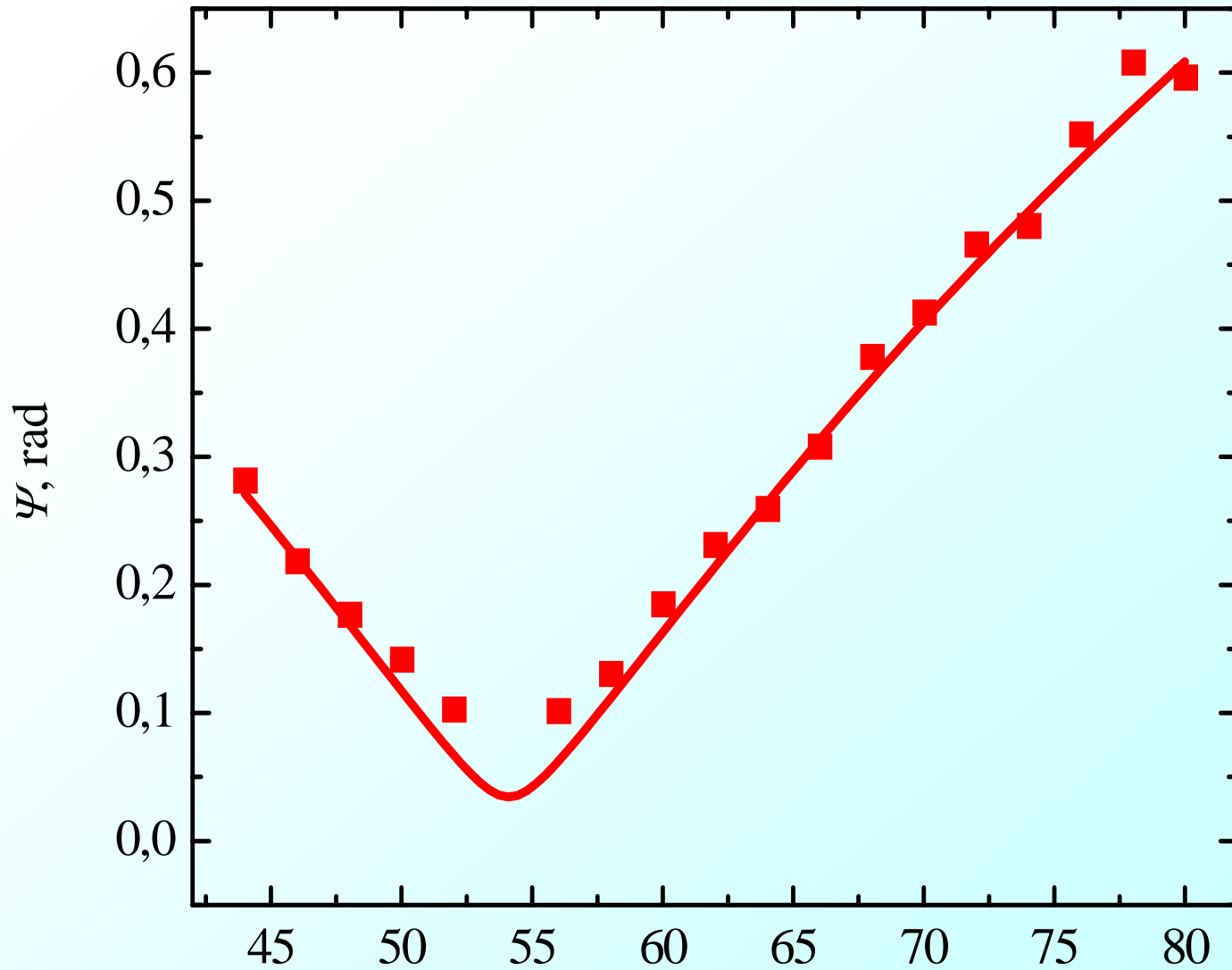
Besisukančių elementų elipsometrija



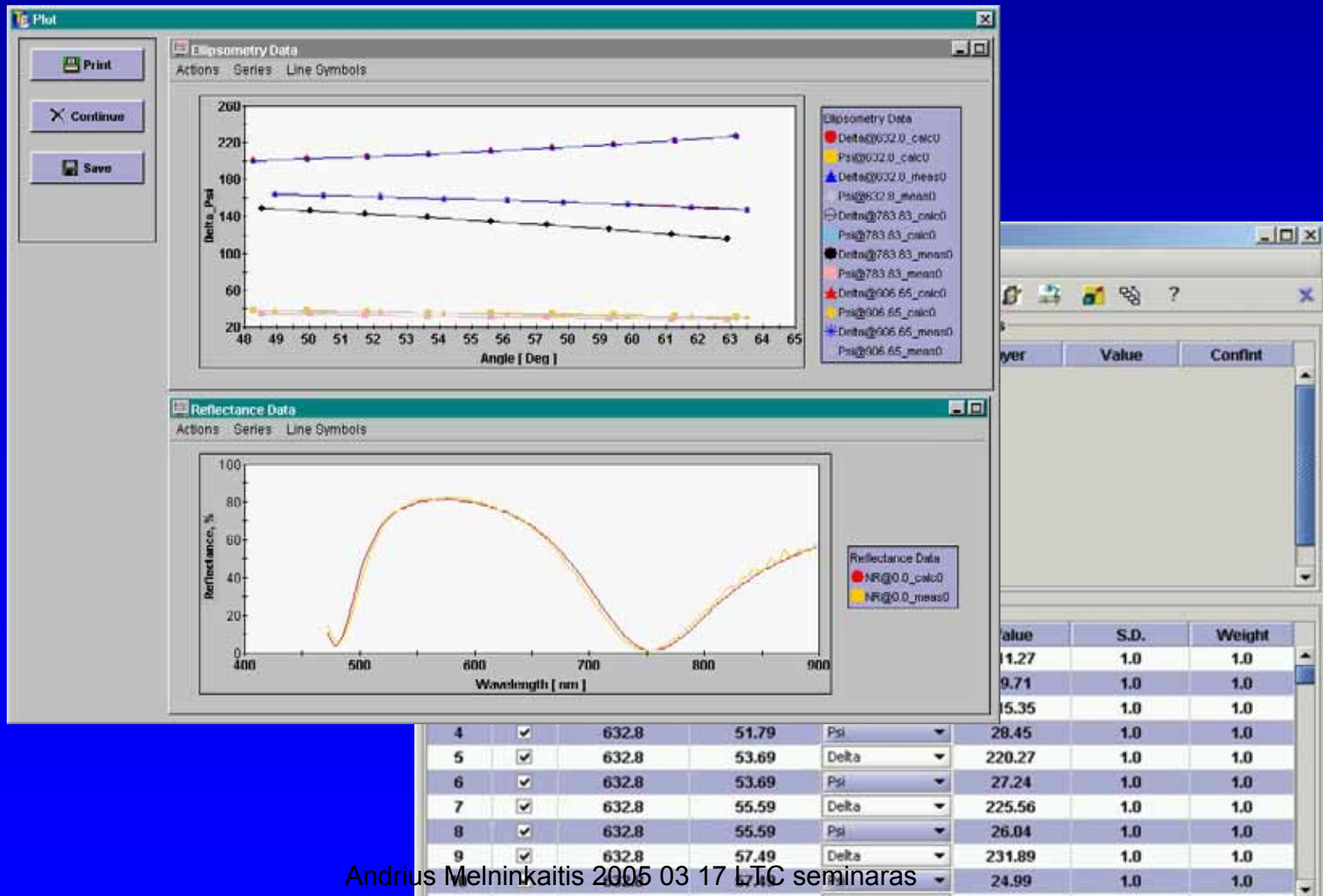
Rezultatų analizės schema





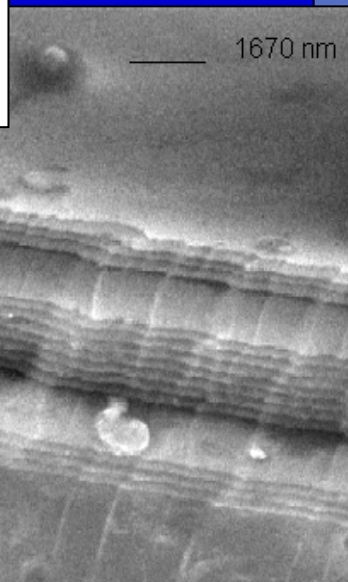
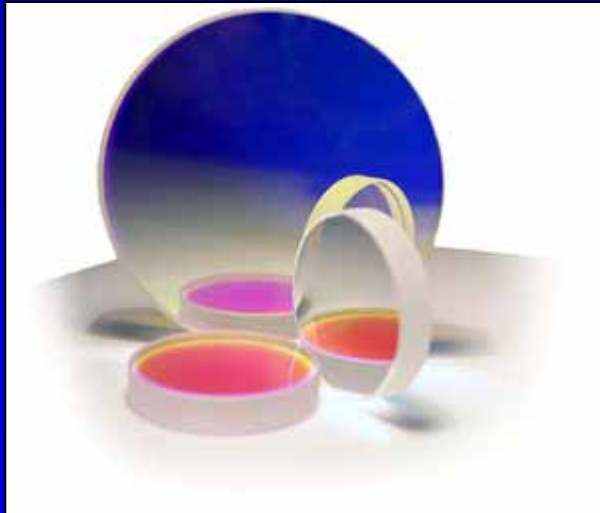


Programinė įranga



Elipsometrijos taikymo sritys

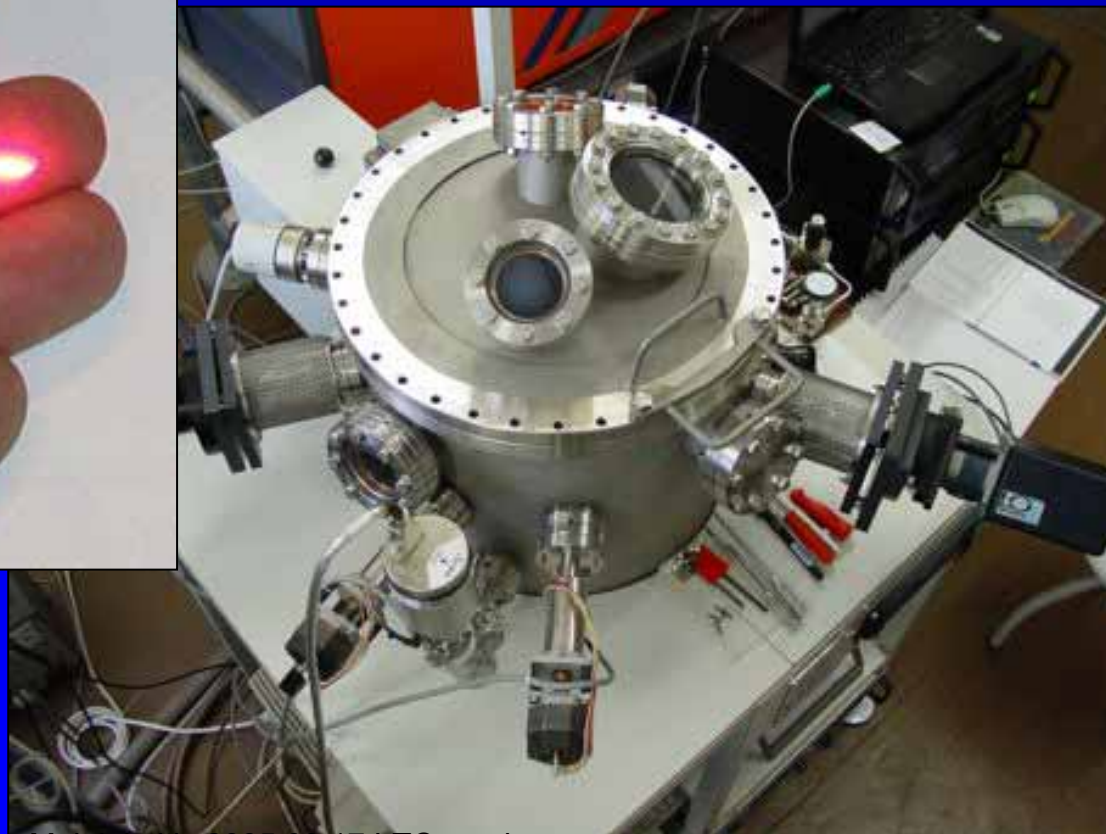
Optinių dangų charakterizavimas



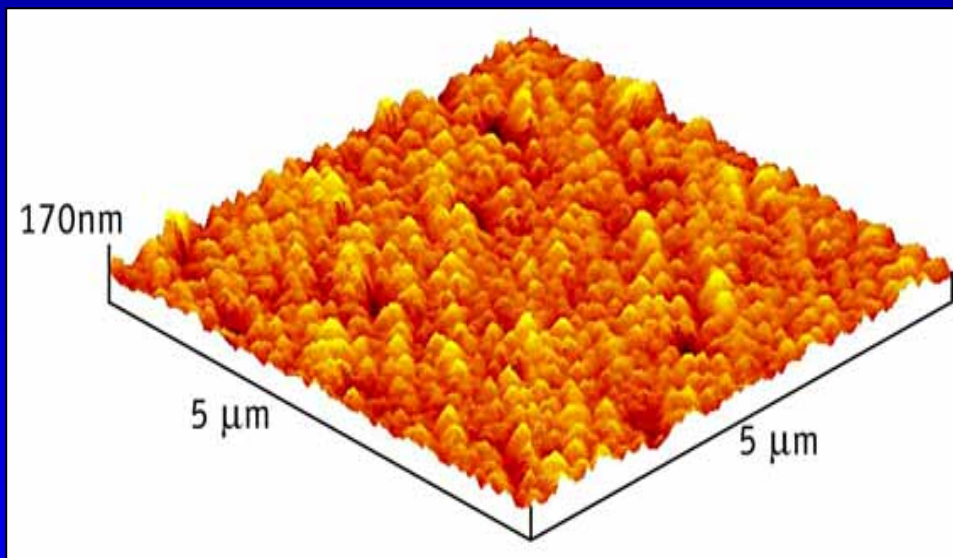
<http://www.jawooliam.com/vuvvase.html>

Andrius Melninkaitis 2005-03-17 LTC seminaras

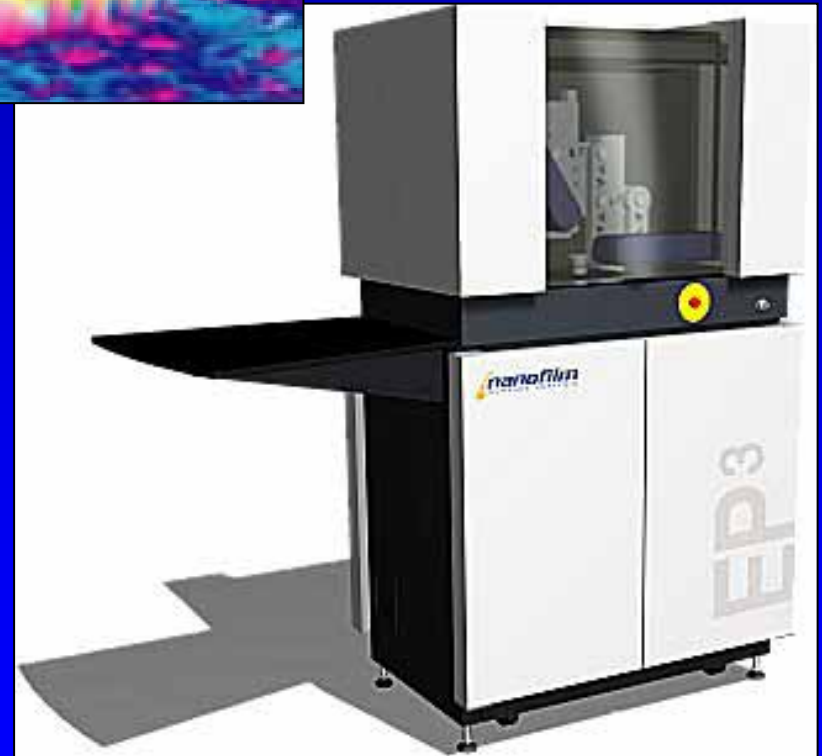
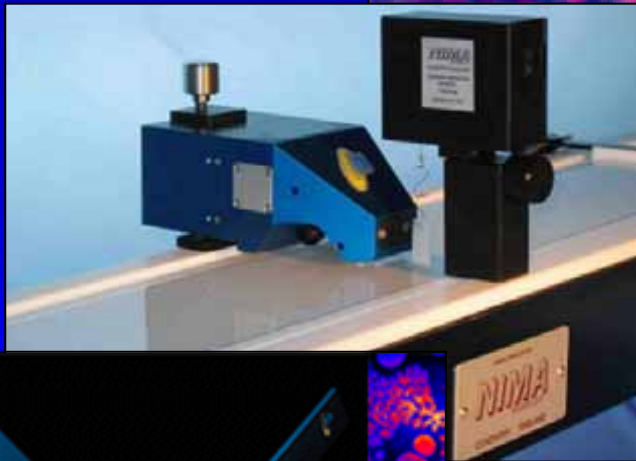
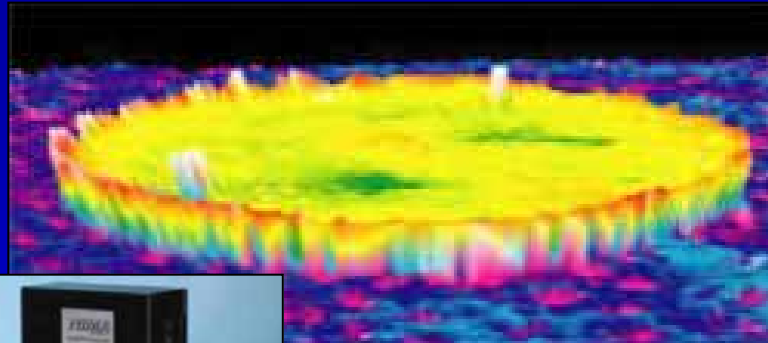
Kintančių procesų stebėjimas (In-Situ)



Paviršiaus kokybės analizė



Briusterio kampo mikroskopija



Ačiū už dėmesį!