THESIS

MEASUREMENT OF He-Ne LASER WAVELENGTH FOR CALIBRATION OF METER STANDARD ACCORDING TO THE SI DEFINITION

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THESIS APPROVAL

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THESIS

MEASUREMENT OF He-Ne LASER WAVELENGTH FOR CALIBRATION OF METER STANDARD ACCORDING TO THE SI DEFINITION

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A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
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Kanokpoj Areekul 2007: Measurement of He-Ne Laser Wavelength for Calibration of Metre Standard According to the SI Definition. Master of Science (Metrology), Major Field: Metrology, Department of Physics. Thesis Advisor: Associate Professor Bancha Panacharoensawad, Dr.Ing. 95 pages.

Metrology is a new area of study and research in our country. Standard unit of length is one of seven basic standard SI units that calibration requirement demand is 50% of all. Calibration of length and related quantities require traceability to the SI. According to the SI definition of meter in 1983, CIPM recommends (CI-1983) three methods of meter realization. The possible and accurate method is the application of interferometer to measure the wavelength of some standard source such as stabilized HeNe laser. This thesis is proposed to apply scanning confocal Fabry-Perot interferometer for wavelength measurement.

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Student’s signature	Thesis Advisor’s signature	

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Kanokpoj Areekul
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LIST OF ABBREVATIONS

atm	=	atmosphere (relative unit of pressure, not SI)
^{A}I	=	Symbol of Element “Iodine Isotope A”
BIPM	=	Bureau International des Poids et Mesures
CCDM	=	Consulting Committee for the Definition of the Metre
CCL	=	Consultative Committee for Length
CCM	=	Comité Consultatif pour la Masse et les Grandeurs Apparentées
CCTF	=	Consultative Committee for Time and Frequency
CEI	=	Commission Electrotechnique Internationale
CGPM	=	Conférence Générale des Poids et Mesures
CIE	=	Commission Internationale de l’Eclairage
CIML	=	International Committee for Legal Metrology
CIPM	=	International Committee of Weight and Measures
CO_2	=	Carbondioxide molecule
Cs	=	Symbol of Element “Cesium”
^{o}C	=	degree Celcius
DTI	=	Department of Trade & Industry (UK.)
esa	=	European Space Agency
Eq.	=	Equation
FIR	=	Far Infrared
FPI	=	Fabry-Perot Interferometer
FSR	=	Free Spectral Range
FWHM	=	Full Width at Half Maximum
fm_{1983}	=	femtometer (according to 1983 meter definition)
GHz	=	GigaHeartz
HeNe, He-Ne	=	Helium Neon
IAU	=	International Astronomical Union
ISO	=	International Organization for Standardization
ISO	=	The Infrared Space Observatory
LASER, laser	=	Light Amplification by Stimulated Emission Radiation

LIST OF ABBREVATIONS (continued)

LWS	=	Long Wavelength Spectrometer)
mm	=	millimeter
m/s	=	Meter per second
m/s^2	=	Meter per square second
m_{1960}^{-1}	=	per meter (according to 1960 meter definition)
MHz	=	MegaHeartz
MRA	=	Mutual Recognition Arrangement
MW	=	Megawatt
mW	=	Milliwatt
nm	=	nanometer
NPL	=	Nation Physics Laboraoty (UK.)
N. A.	=	Not Available
N/A^2	=	Newton per square Ampare
N/V	=	Newton per Volt
OPD	=	Optical Path Difference
OSA	=	Optical Spectrum Analyzer
PTB	=	Physikalisch-Technische Bundesanstalt (Ger.)
RegMet	=	Metrology For Improved Measurement In International Regulation And Trade
SI	=	Systbme International
Torr.	=	Torr. (1 Torr. = 1 mmHg, relative unit of pressure, not SI)
VLB	=	Very Long Baseline Measurements
V·s/A·m	=	Volt-second per Ampare-meter
μm	=	micrometer
^{86}Kr	=	Krypton atom isotope 86
^{198}Hg	=	Mercury atom isotope 198
^{114}Cd	=	Cadmium isotope 114
^{127}I	=	Iodine atom isotope 127
^{129}I	=	Iodine atom isotope 129

LIST OF SYMBOLS AND VARIABLES

A	=	Surface Losses Coefficients
$a(r, z)$	=	Gaussian Beam Distance
$\mathbf{b}$	=	Gravitation Fields
c, c_{mat}	=	Speed of Light Propagating in Material
c_o, c_{vac}	=	Speed of Light in Free Space or in Vaccuum
d	=	Distance of Mirrors, along the optical axis of the cavity
E	=	Photons of energy,
E_t	=	Magnitude of Electric Field Component of transmitted rays
E	=	Magnitude of Electric Field Component, of electromagnetic wave
E_{rp}	=	Magnitude of Electric Field Component of reflected ray "*p*"
E_r*	=	Conjugate of Magnitude of Electric Field Component
F	=	The Co-efficient of Finesse or Contrast
g	=	Acceleration due to Earth Gravitation
H	=	Plank's constant
I_r	=	Intensity of Reflected Rays
I	=	Intensity of Rays
I_t	=	Intensity of transmitted Rays
k	=	Coverage Factor
k (ku_c)	=	Coverage factor for combine uncertainty
k, k_0	=	Circular Wave Number ($2\pi/\lambda$) in Medium n, n_o
m	=	Mass of Particle
m, n	=	Rectangular Mode Numbers (in metrology only $m = n = 0$ is of interest)
n, n_o	=	Refractive Index
$n(\lambda)$	=	Dispersion of The Refractive Index,
q	=	Number of Nodes, in a standing wave between the mirrors
$q + 1$	=	The order of interference as usual.
r	=	Distance on Radial Direction
r	=	Internal Amplitude Reflection Coefficients
r'	=	External Amplitude Reflection Coefficients

LIST OF SYMBOLS AND VARIABLES (continued)

r_1, r_2	=	Radii of Curvature, of the spherical mirrors
R	=	Reflectance (= r^2)
t	=	Internal Amplitude Transmission Coefficients
t'	=	External Amplitude Transmission Coefficients
t	=	Time
T	=	Transmittance (= tt')
T	=	Period of Electromagnetic Wave
THD	=	Total Harmonic Distorsion
$THD\%$	=	Percentage Total Harmonic Distorsion
u_c/y, u_{rel}	=	Relative Combine Uncertainty of variable y
u_c	=	Combined Uncertainty
U	=	Uncetainty (total)
w_0	=	Beam Waist
x	=	Distance on z Axis
z	=	Height, Distance on z Axis
ε_o	=	Electric Field Constant or Permittivity of the Vacuum
$\Delta\lambda_{FSR}$	=	Free Spectral Range (in term of wavelength)
Δf_{FSR}	=	Free Spectral Range (in term of frequency)
$\Delta\lambda_{res}$	=	Resolution (in term of wavelength)
λ	=	Wavelength
φ	=	Gravitation Potential
ν	=	Frequency of Electromagnetic Wave
Δr	=	Traveling Path in Gravitation Potential Field
ν_q	=	Resonance Frequency of a Mode Matched Wave,
ν_o	=	Frequency Distance Between Neighboring Longitudinal Resonant Modes, counted by the integer q, $\nu_o = \frac{c_o}{2d}$
μ_0	=	Permeability of the Vacuum
δ	=	Phase Difference Between Adjacent Reflected Rays

LIST OF SYMBOLS AND VARIABLES (continued)

φ, φ_o	=	Phase Difference
θ, θ', θ_o	=	Angle
δ	=	Optical Path Difference between two adjacent rays
ω	=	Angular Frequency
σ	=	Spatial Periods per Unit of Length ($k/2\pi$)
$\Im$	=	Finesse
ϕ	=	Phase Change Upon Reflection