

Article

Wavelength Calibration for an External Cavity Diode Laser Using a Polynomial Dual-Cosine Model

Suman Ai ^{1,2}, Ruifeng Kan ², Cheng Du ³, Zhongqiang Yu ³, Weiqi Xing ³, Dingfeng Shi ², Chuge Chen ², Rantong Niu ², Zhenyu Xu ^{2,*} and An Huang ^{2,*}

¹ School of Environmental Science and Optoelectronic Technology, University of Science and Technology of China, Hefei 230026, China; smai@aiofm.ac.cn

² Anhui Institute of Optics and Fine Mechanics, Hefei Institutes of Physical Science, Chinese Academy of Sciences, Hefei 230026, China; kanruifeng@aiofm.ac.cn (R.K.); shidf@aiofm.ac.cn (D.S.); cgchen@aiofm.ac.cn (C.C.); rtniu@aiofm.ac.cn (R.N.)

³ AECC Shenyang Engine Research Institute, Shenyang 110000, China; dcddc_002@163.com (C.D.); yuzhqi2023@163.com (Z.Y.); x1561172218@163.com (W.X.)

* Correspondence: zyxu@aiofm.ac.cn (Z.X.); ahuang@aiofm.ac.cn (A.H.)

Abstract

A polynomial dual-cosine model is proposed for the wavelength calibration of an ECDL (Santec-TSL710-O-band). An analysis of the ECDL's measured spectral data demonstrates that the polynomial dual-cosine model reduces the relative wavenumber fitting residuals by a factor of five within a scanning range of 30 cm^{-1} . The experimental results of broadband temperature measurement (700~1600 K) in the tube furnace confirm that the proposed model successfully reduces the maximum temperature relative error from 6.7% to 2.3%. The wavelength calibration model effectively promotes further research on the broadband absorption spectroscopy thermometry method and its application in the temperature diagnostics of aeroengine combustors.

Keywords: wavelength shift; the external cavity diode laser of model Santec-TSL710-O-band; polynomial dual-cosine wavelength calibration model; temperature measurement



Received: 1 September 2025
Revised: 24 September 2025
Accepted: 26 September 2025
Published: 29 September 2025

Citation: Ai, S.; Kan, R.; Du, C.; Yu, Z.; Xing, W.; Shi, D.; Chen, C.; Niu, R.; Xu, Z.; Huang, A. Wavelength Calibration for an External Cavity Diode Laser Using a Polynomial Dual-Cosine Model. *Photonics* **2025**, *12*, 964. <https://doi.org/10.3390/photonics12100964>

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1. Introduction

Accurate temperature measurement in extreme combustion environments, such as scramjet (700~2500 K) [1] and rocket combustors (25~105 bar) [2,3], is critical for enhancing combustion performance and emission control in advanced propulsion systems. Tunable diode laser absorption spectroscopy (TDLAS) has emerged as a preferred technique for non-intrusive combustion diagnostics due to the merits of high accuracy, real-time capability, and robustness in harsh combustion environments [4–7]. However, traditional single-line and two-line thermometry suffers from significant accuracy degradation in high-temperature and high-pressure combustion environments [8–10].

The broadband multi-line thermometry method based on TDLAS direct absorption spectroscopy enables the acquisition of continuous wideband absorption spectra, which contain highly rich spectral information. Different absorption features within the broad spectral band exhibit distinct sensitivities to various temperature intervals, making this approach particularly advantageous for temperature diagnostics across a wide operating temperature range [11–16]. Moreover, spectral line blending under high-pressure conditions can cause blurred absorption features and reduced temperature measurement sensitivity. Broadband absorption spectroscopy is highly effective in addressing such

high-pressure-related challenges [17]. Therefore, to meet the demanding temperature measurement requirements in aeroengine applications involving wide operational conditions and highly dynamic environments, broadband absorption spectroscopy represents a promising solution. The implementation of this technique relies critically on light sources with wide tuning ranges, with its core advantage lying in the ability to cover multiple absorption lines in a single scan. Currently available commercial light sources, such as VCSELs (Vertical Cavity Surface Emitting Lasers) [18], FDMLs (Fourier Domain Mode Locked lasers) [19], and supercontinuum (SC) lasers [20], often suffer from large linewidths and impose high demands on hardware system bandwidth and response speed. The external cavity diode laser (ECDL) of model Santec-TSL710-O-band used in the present work exhibits unique advantages for combustion diagnostics. The narrow linewidth (100 kHz) of the ECDL can help achieve precise spectral resolution and accurate discrimination of H₂O absorption features. Furthermore, the wavelength scanning range (1260~1360 nm) of the ECDL strategically covers commonly used H₂O absorption lines in combustion diagnostics [21,22], thereby recording a lot of spectral information across wide dynamic temperature and pressure ranges. And the ECDL-integrated TDLAS temperature measurement system features a more simplified configuration. These capabilities of the ECDL are particularly critical for temperature measurement in combustion environments where thermal gradients coexist and pressure increases. However, despite these advantages, the ECDL manifests wavelength drift during spectral scanning. This problem is caused by mechanical vibrations and cumulative stepping errors in its motor-controlled tuning system. Such drift generates nonlinear spectral shifts that distort absorption line positions, ultimately reducing temperature measurement accuracy.

Various advanced wavelength calibration methods exist. Machine learning [23] holds potential for compensating complex nonlinear wavelength-related impairments. However, it often requires extensive data for training, exhibits relatively poor model interpretability, and may involve high computational complexity. Fourier transform spectrum analysis and similar methods [24] are powerful tools for analyzing periodic signals. Nevertheless, the Fourier method is a global transformation that struggles to capture the local variation characteristics of the ECDL as described in the paper, such as nonlinear drift and periodic fluctuations. Secondly, the physical meaning of the extracted frequency components may be ambiguous. The higher-order etalon calibration technique [25] can meet the requirements of wide-range wavelength tuning and high-precision frequency stabilization in precision interferometry, but these systems are generally more complex and costly.

To address the wavelength drift of the ECDL (Santec-TSL710-O-band), we propose a polynomial dual-cosine (PDC) model for wavelength calibration. Compared to the above advanced wavelength calibration methods, the design of the PDC model provides a tailored solution for the wavelength drift problem in the target ECDL where the drift is caused by specific physical mechanisms, and its periodic characteristics are known a priori through preliminary calibration (e.g., etalon spectrum analysis). Its advantages are demonstrated in physical interpretability, the precise capture of drift features, computational efficiency, low cost, and a stronger potential for real-time applications. The performance of the PDC model under varying scan ranges was assessed by analyzing the ECDL's measured spectral data. A high-temperature experiment (700~1600 K) in the tube furnace was conducted to evaluate the improvement in broadband temperature measurement accuracy enabled by the PDC wavelength calibration model.

2. Theoretical Principles of Wavelength Drift

The ECDL (Santec-TSL710-O-band) employed in this study adopts a Littman–Metcalf configuration, with its physical unit and internal architecture illustrated in Figure 1.

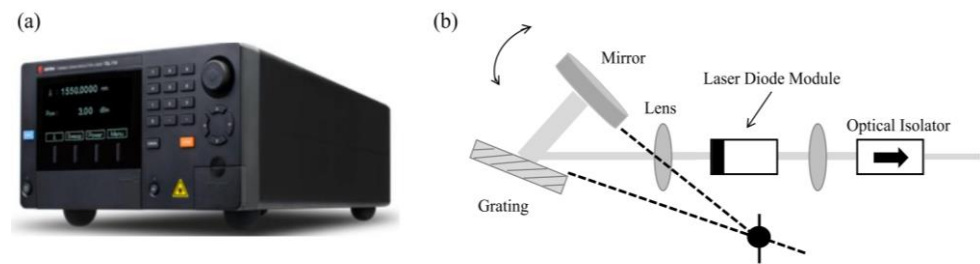


Figure 1. (a) Physical unit of ECDL. (b) Internal architecture of ECDL.

The laser diode module generates optical radiation spanning the 1260~1360 nm telecommunication band. Emitted light is dispersed by a diffraction grating, directing wavelength-specific beams toward a reflective mirror. Then, reflected light couples back into the ECDL fiber output port. Wavelength tuning is achieved by controlling the angle of the reflective mirror using a motor. The wavelength tuning range expands with increased mirror rotation angle, whereby the precision mechanical rotation of the reflective mirror enables mode-hop-free continuous tuning across the operational spectral band. Wavelength selection is governed by Equation (1):

$$\lambda = \frac{2d}{m} \sin \theta \quad (1)$$

Here, d denotes the grating constant; m represents the diffraction order; θ is the angle of the reflective mirror.

However, during ECDL operation, the inherent reciprocal vibrations of the mechanical motor and cumulative stepping errors induce minute angular displacements in the mirror rotation mechanism. These deviations directly translate to angular misalignments of the reflective mirror, thereby generating wavelength drift that compromises spectral calibration accuracy. Figure 2 illustrates the wavelength drift in the ECDL scanning range of 1350~1360 nm. Each set of transmission intensity signals exhibits irregular wavelength drift, with the number of drift points varying among the groups.

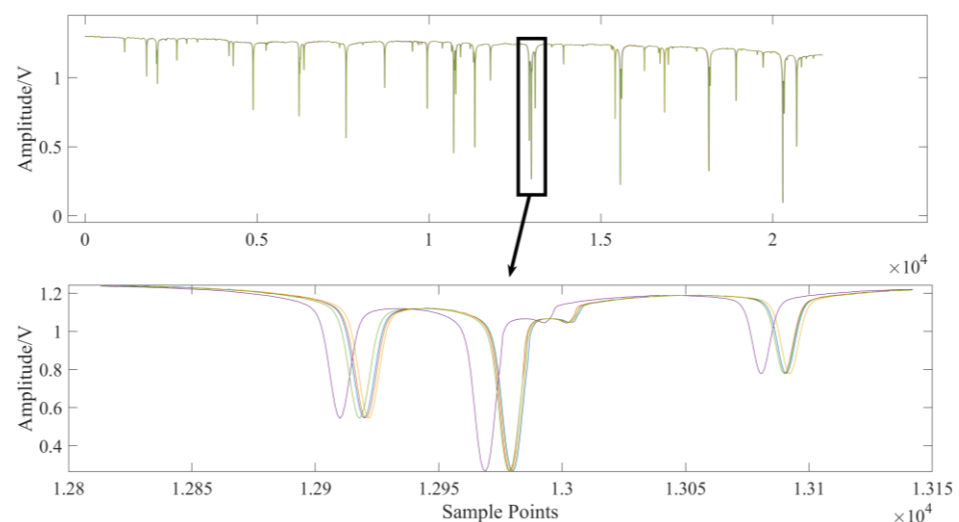


Figure 2. Transmission intensity corresponding to 1350~1360 nm.

3. Wavelength Calibration

3.1. Polynomial Dual-Cosine Model

To address the irregular wavelength drift patterns in the ECDL (Santec-TSL710-O-band), we employed a quartz etalon to capture interference signals and developed a polynomial

dual-cosine wavelength calibration model to reduce the relative wavenumber error. The proposed model is formulated as Equation (2):

$$\nu_{poly_cos_fit} = \sum_{k=0}^n c_k loc^k + \left[A1 \cos\left(\frac{2\pi \cdot loc}{T1} + \varphi1\right) + A2 \cos\left(\frac{2\pi \cdot loc}{T2} + \varphi2\right) \right] \quad (2)$$

In this equation, $\nu_{poly_cos_fit}$ represents the relative wavenumber fitted by the PDC model; k denotes the order of the polynomial fit; c_k corresponds to the coefficients of the k -order polynomial to be optimized; loc represents the interference peak positions of etalon signals. $A1$ and $A2$ are the amplitudes of the two cosine terms, quantifying the residual values of polynomial fitting; $T1$ and $T2$ define the periods of the two cosine terms, derived from the periodic residual intervals of the polynomial fitting; $\varphi1$ and $\varphi2$ are the phase offsets of the cosine terms, initialized to zero during fitting to ensure alignment with the polynomial fitting residuals.

A flowchart of the polynomial dual-cosine wavelength calibration model is detailed in Figure 3.

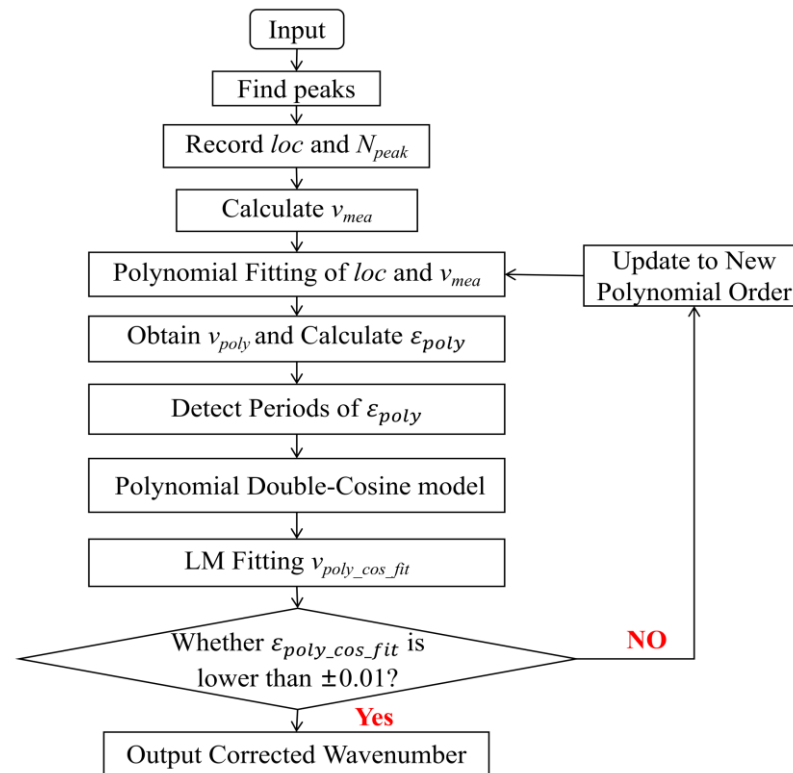


Figure 3. Flowchart of polynomial dual-cosine wavelength calibration model.

The optimization procedure, parameter selection, and error convergence criteria in Figure 3 are detailed as follows:

- (1) Etalon Signal Processing: The etalon interference signal is input, and peak detection is performed to record the peak positions of etalon signals (denoted as loc) and the number of interference peaks (denoted as N_{peak}).
- (2) Relative Wavenumber Calculation: The measured relative wavenumber (denoted as ν_{mea} , $\nu_{mea} = N_{peak} \cdot FSR$) is calculated using N_{peak} and the etalon's free spectral range (FSR).
- (3) Polynomial Residual Analysis: Polynomial fitting is commonly employed to establish the relationship between ν_{mea} and loc . Then the fitted relative wavenumber (denoted

as ν_{poly}) can be obtained. The residuals between ν_{mea} and ν_{poly} are defined as ε_{poly} ($\varepsilon_{poly} = \nu_{mea} - \nu_{poly}$). The process of polynomial fitting is shown in Figure 4.

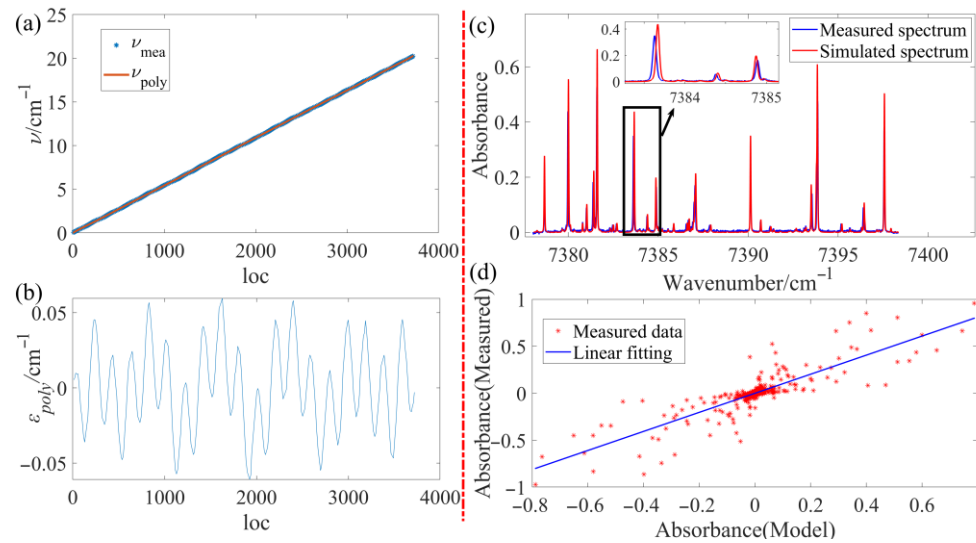


Figure 4. (a) Polynomial fitting of loc and ν_{mea} . (b) Values of ε_{poly} . (c) Simulated spectrum and polynomial wavelength-calibrated spectrum (@1000 K). (d) Spectral linear fitting between Abs_{mea} and Abs_{model} .

Figure 4a,b illustrate how the polynomial fitted ν_{poly} and presents the values of ε_{poly} fluctuating between -0.063 and 0.067 . The Root Mean Square Error (RMSE) for ε_{poly} is 0.0207 . The waveform of ε_{poly} has regular periodic variations, indicating that the ECDL's vibrations of the mechanical motor are similar to ε_{poly} . ν_{poly} was converted to the absolute wavenumber (denoted as ν_{abs_mea}) and compared with the true wavenumber values (denoted as ν_{abs_sim}) of the simulated spectrum, as shown in Figure 4c. ν_{abs_mea} deviates from the true ν_{abs_sim} . The first derivative of the polynomial wavelength-calibrated spectrum was calculated and then input into our established broadband H₂O absorption spectroscopy thermometry model [26,27]. As shown in Figure 4d, the spectral fitting results were poor, indicating the noticeable deviation of the measured spectrum (denoted as Abs_{mea}) from the theoretical broadband absorption spectrum (denoted as Abs_{model}). These results suggest that the conventional polynomial fitting method for the wavelength calibration of the ECDL introduces considerable errors. But it is worth noticing that ε_{poly} demonstrates obvious periodic fluctuation, so a dual-cosine function can be introduced to reduce this error.

- (4) Dual-Cosine Parameter Initialization: The periodic amplitudes of ε_{poly} are extracted as $A1$ and $A2$. The periodic intervals of ε_{poly} are extracted as $T1$ and $T2$. These parameters are subsequently used as initial parameters in Equation (2) to iteratively fit the relative wavenumber (denoted as $\nu_{poly_cos_fit}$).
- (5) Iterative Optimization: The residual error between ν_{mea} and $\nu_{poly_cos_fit}$ is denoted as c ($\varepsilon_{poly_cos_fit} = \nu_{mea} - \nu_{poly_cos_fit}$). When $\varepsilon_{poly_cos_fit}$ satisfies a convergence threshold ($\varepsilon_{poly_cos_fit} \leq \pm 0.01$), the calibrated $\nu_{poly_cos_fit}$ is output and converted to the absolute wavenumber using a reference absorption line. The polynomial order k has an effect on the values of ε_{poly} ; then $A1$, $A2$, $T1$, and $T2$ in the dual-cosine function need dynamic adjustment to satisfy the convergence threshold of $\varepsilon_{poly_cos_fit}$. Hence, the polynomial order needs to be iteratively incremented to optimize global nonlinear compensation while the dual-cosine terms suppress the periodic residuals of ε_{poly} . This adaptive refinement cycle progressively enhances calibration precision, and the results are presented in Figure 5. The RMSE for $\varepsilon_{poly_cos_fit}$ is 0.0035 . Compared to Fig-

ure 4, the RMSE and residual of the relative wavenumber in Figure 5 are, respectively, reduced by a factor of 5.9 and 5. The polynomial dual-cosine wavelength-calibrated spectrum has superior agreement with the simulated spectrum. Moreover, spectral fitting shows good linearity and high similarity, indicating that the polynomial dual-cosine model can effectively address the wavelength drift issue of the ECDL.

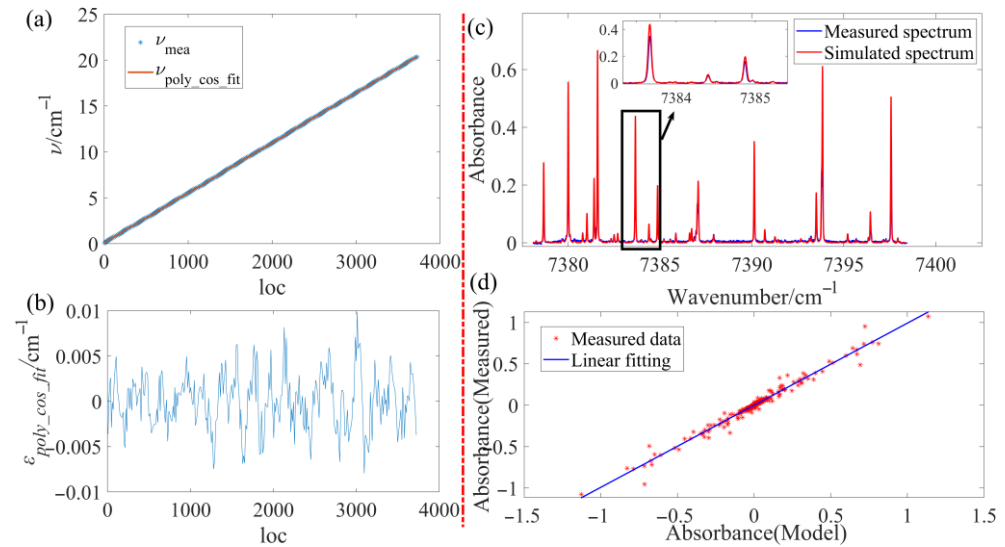


Figure 5. (a) Polynomial dual-cosine fitting of loc and ν_{mea} . (b) Values of $\epsilon_{poly_cos_fit}$. (c) Simulated spectrum and polynomial dual-cosine wavelength-calibrated spectrum (@1000 K). (d) Spectral linear fitting between Abs_{mea} and Abs_{model} .

3.2. An Impact Analysis of the Polynomial Order in the PDC Model

In the polynomial dual-cosine model, it is necessary to update the order of polynomial fitting to control the fitting residuals. However, during the application of polynomial dual-cosine wavelength calibration, it was observed that a higher polynomial order k does not invariably yield better results. The relative wavenumber residuals obtained from fitting with $k = 3, 13$, and 23 are presented in Figure 6.

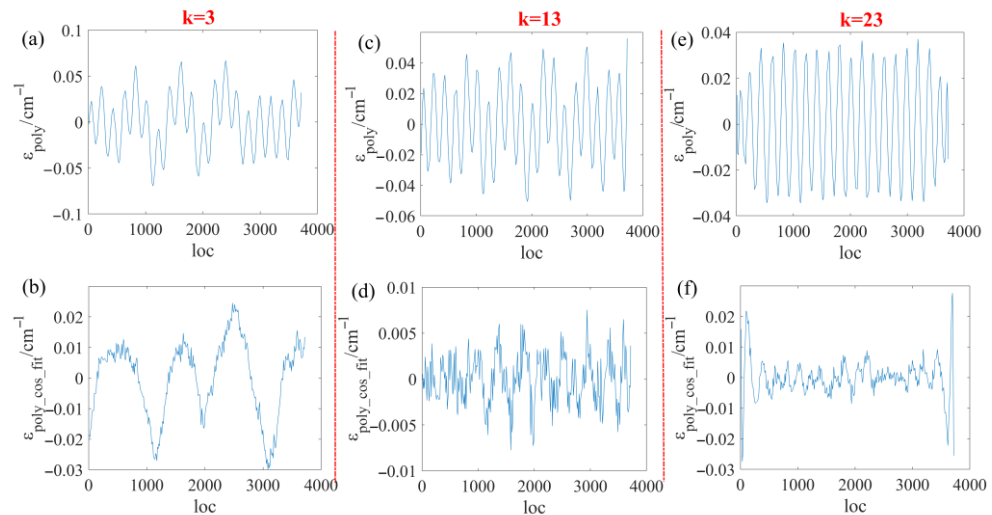


Figure 6. (a) ϵ_{poly} at $k = 3$; (b) $\epsilon_{poly_cos_fit}$ at $k = 3$; (c) ϵ_{poly} at $k = 13$; (d) $\epsilon_{poly_cos_fit}$ at $k = 13$; (e) ϵ_{poly} at $k = 23$; (f) $\epsilon_{poly_cos_fit}$ at $k = 23$.

Based on the analysis of Figure 6a,b, when k is 3, $\epsilon_{poly_cos_fit}$ decreases by approximately 0.6 times compared to ϵ_{poly} after applying the PDC model. However, significant periodic fluctuations persist in $\epsilon_{poly_cos_fit}$. This occurs because an excessively low order

fails to capture the complex trends in the data under wide scanning ranges, resulting in high residual errors in ε_{poly} . Even with polynomial dual-cosine correction, the wavelength calibration requirements cannot be met. An analysis of Figure 6c,d shows that at $k = 13$, ε_{poly} is smaller than that at $k = 3$, indicating that increasing the order helps reduce fitting errors. $\varepsilon_{poly_cos_fit}$ decreases by approximately 6 times compared to ε_{poly} . A further analysis of Figure 6e,f reveals that at $k = 23$, although ε_{poly} is smaller than at $k = 13$, the excessively high order overfits the data characteristics. This leads to significantly larger residuals in $\varepsilon_{poly_cos_fit}$ at peak positions 1~300 and 3500~3700 compared to those at positions 300~3500, resulting in an overall poorer relative wavenumber fitting performance.

It is necessary to evaluate the variations in ε_{poly} and $\varepsilon_{poly_cos_fit}$ across different polynomial orders to identify an optimal order that avoids underfitting or overfitting. The maximum values of the relative wavenumber fitting residuals were calculated for polynomial orders ranging from 1 to 100, as shown in Figure 7.

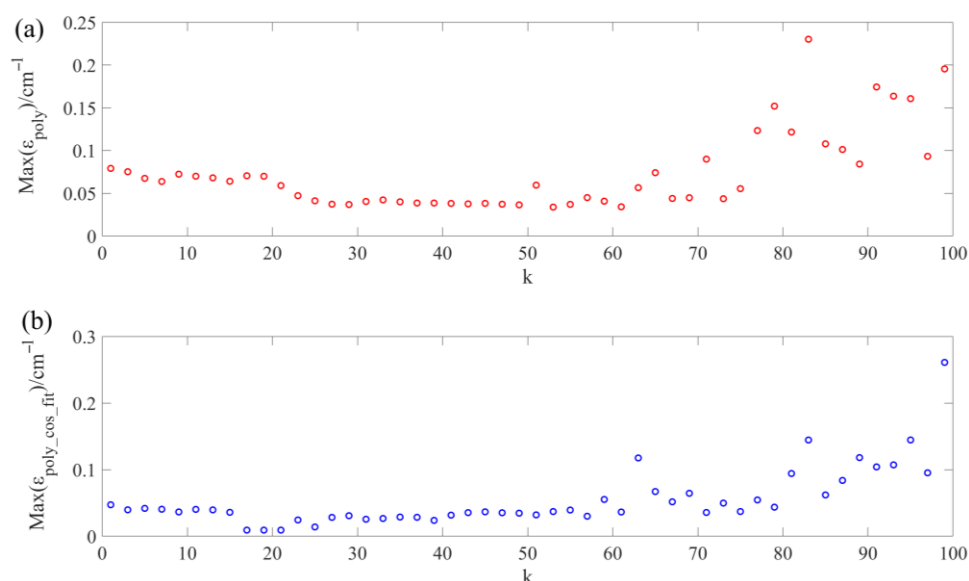


Figure 7. (a) $\text{Max}(\varepsilon_{poly})$ at $k = 1\sim 100$; (b) $\text{Max}(\varepsilon_{poly_cos_fit})$ at $k = 1\sim 100$.

In Figure 7a, for orders 1 to 27, ε_{poly} decreases with increasing order, reaching a minimum value of 0.037 at $k = 29$. From $k = 29\sim 49$, ε_{poly} gradually increases to 0.04 and remains nearly constant. Beyond order 49, ε_{poly} becomes larger and exhibits irregular fluctuations, indicating that very high orders contribute no further improvement to the fitting. Correspondingly, in Figure 7b, $\varepsilon_{poly_cos_fit}$ for orders 17 to 21 stabilizes around 0.0091 and reaches the minimum values. Beyond order 21, $\varepsilon_{poly_cos_fit}$ slowly increases and shows irregular variations. This demonstrates that when ε_{poly} is minimized, the corresponding polynomial order can no longer be effectively used in the dual-cosine model fitting, as it is highly prone to overfitting. This conclusion is consistent with the results shown in Figure 6. When using the polynomial dual-cosine model for fitting, the maximum k should be constrained within 21. This ensures optimal fitting performance while avoiding overfitting and ill-conditioned solutions caused by high-order polynomials.

3.3. An Impact Analysis of the Scanning Range in the ECDL

Different scanning ranges of the ECDL can be selected for temperature measurement. However, varying the scanning range leads to differences in the number of relative wavenumber samples used for fitting. Therefore, it is necessary to evaluate the maximum wavelength correction capability of the polynomial double-cosine model. To avoid overfitting and underfitting, the maximum polynomial order in the iterative process (as shown in

Figure 7) was limited to 21. The results of $\varepsilon_{poly_cos_fit}$ were calculated for continuous scanning ranges (denoted as $\Delta\nu$) of 5 cm⁻¹, 10 cm⁻¹, 20 cm⁻¹, 30 cm⁻¹, 40 cm⁻¹, and 50 cm⁻¹, as shown in Figure 8.

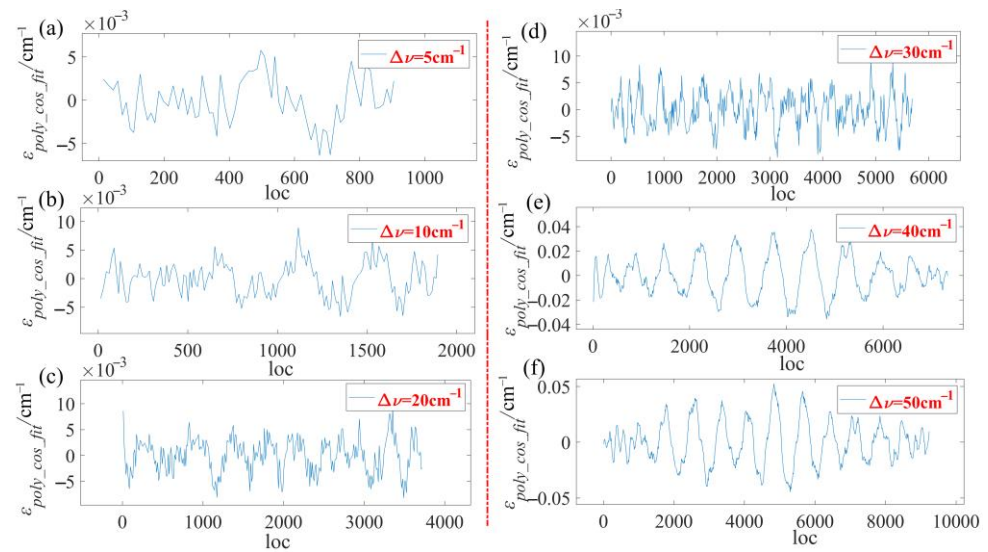


Figure 8. (a) $\varepsilon_{poly_cos_fit}$ at $\Delta\nu = 5$ cm⁻¹; (b) $\varepsilon_{poly_cos_fit}$ at $\Delta\nu = 10$ cm⁻¹; (c) $\varepsilon_{poly_cos_fit}$ at $\Delta\nu = 20$ cm⁻¹; (d) $\varepsilon_{poly_cos_fit}$ at $\Delta\nu = 30$ cm⁻¹; (e) $\varepsilon_{poly_cos_fit}$ at $\Delta\nu = 40$ cm⁻¹; (f) $\varepsilon_{poly_cos_fit}$ at $\Delta\nu = 50$ cm⁻¹.

The values of $\varepsilon_{poly_cos_fit}$ are all smaller than ± 0.01 when the scanning ranges are 5 cm⁻¹~30 cm⁻¹, with the polynomial order ranging from 3 to 17. As the scanning range increases, a higher-order polynomial is required, enabling the construction of more complex functions to accommodate large-scale variations. However, when the scanning range is increased to 40 cm⁻¹~50 cm⁻¹, the values of $\varepsilon_{poly_cos_fit}$ fluctuate within ± 0.05 , and the polynomial order reaches 19. Even with higher-order polynomials, the larger fitting range requires substantial adjustments to the higher-order coefficients, forcing the polynomial double-cosine model to compensate for the large deviation using extreme coefficient values. This leads to a fitting result that deviates from the true trend. The results suggest that the polynomial double-cosine model is more suitable for wavelength calibration within a scanning range of 30 cm⁻¹. When the scanning range of the ECDL is greater than 30 cm⁻¹, wavelength calibration can be performed in segments to ensure high calibration accuracy.

4. Experimental Setup and Discussions

4.1. Experimental Setup

The temperature measurement performance of the ECDL after wavelength calibration was validated using a tube furnace, which is a custom-built system featuring a three-zone heating configuration. Each zone is independently controlled and monitored by embedded thermocouples, with inter-zone temperature variations maintained within ± 2 °C, demonstrating excellent thermal stability. The experimental setup is shown in Figure 9. Four optical paths were set up using a 1×4 beam splitter, with the signal from each path being received by one of the four detectors (PD1, PD2, PD3, PD4). PD1 receives the reference signal, and the H₂O absorption signal from the high-temperature tube furnace is captured by PD2. Furthermore, the signal captured by PD1 can be used for the synchronous subtraction of PD2's irregular baseline and residual H₂O absorption in room air. Both Path 1 and Path 2 use homemade fiber-coupled detectors from our research group. PD3 and PD4 simultaneously acquire the signals from the etalon and air, respectively. The H₂O absorption in the air at optical path lengths L1 and L2 causes difficulties in the peak

detection of the etalon interference signal. The signal received by PD4 can be used to subtract the H₂O absorption in the PD3 signal. The optical path length in PD4 is the sum of the optical path length of L1 and L2. For the easier setup of optical alignment, both Path 3 and Path 4 use commercial detectors (model: Thorlabs PDA10D-E-C). Although two types of detectors are used in Figure 9, resulting in differences in signal amplitude between optical paths, signal fidelity remains undistorted. The signals from the four detectors were recorded by a computer (NI, PXIe-5172).

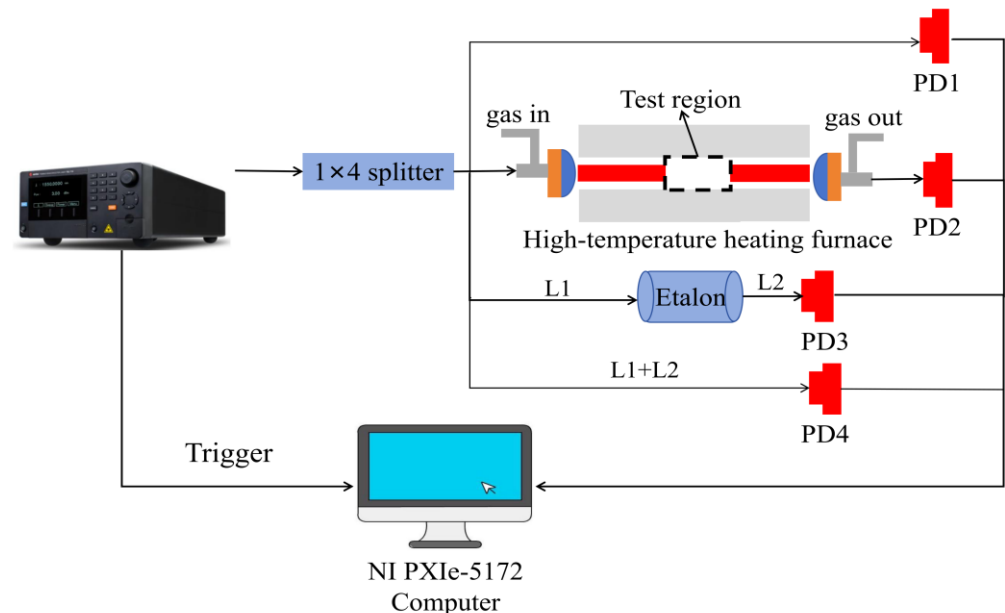


Figure 9. Experimental setup of ECDL (Santec-TSL710-O-band).

4.2. Results and Discussions

The ECDL scanning range is set from 1330 nm to 1360 nm, within which only H₂O molecular absorption is present. The entire wavelength range is scanned at a speed of 100 nm/s, with 30,000 data points collected per cycle. Ten equally spaced temperatures ranging from 700 K to 1600 K were set in the tube furnace. When the high-temperature tube furnace indicates that it has reached the set temperature, pure water vapor at 3.5 kPa was introduced into the tube furnace. The furnace pressure is monitored by an MKS628 pressure gauge. After the pressure stabilizes for 10~20 min, the transmitted light intensity signals from the four optical paths are collected.

As shown in Figure 10, at 800 K, the four transmitted light intensity signals were detected by PD1, PD2, PD3, and PD4.

Throughout the entire scanning range, the H₂O absorption in the high-temperature tube furnace (as seen in PD2) is significant. The signal envelope of PD1 is relatively consistent with that of PD2. Between the 20,000th and 30,000th sample points, numerous low-temperature absorption lines are present. At room temperature, partial H₂O absorption occurs, which serves as a reference signal to accurately extract the absorption features of PD2. PD3 and PD4 have longer optical paths, resulting in stronger room-temperature H₂O absorption at the same sample points as PD1. By utilizing PD4, the interference from this absorption can be effectively eliminated, improving the accuracy of etalon peak detection.

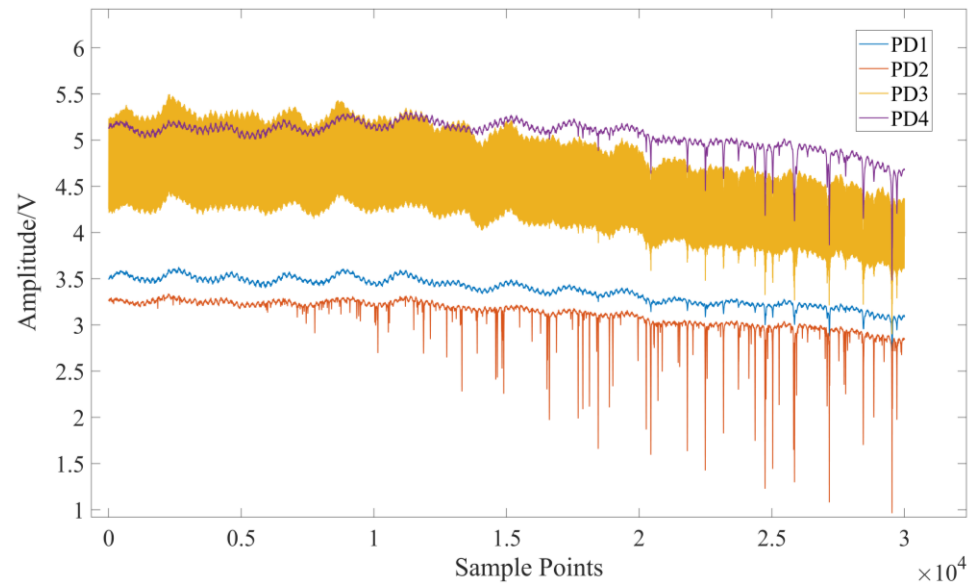


Figure 10. The signals of four optical paths from the ECDL across 1330~1360 nm (@800 K).

The ECDL's continuous scanning range is 166 cm^{-1} in Figure 10. As demonstrated by the simulation results in Section 3.2, the spectral range was divided into 30 cm^{-1} intervals. Then wavelength correction was performed in segments using the polynomial double-cosine model. The calibrated segments were sequentially stitched together. Figure 11 presents the spectral fitting results of the segmented wavelength-calibrated absorption spectrum.

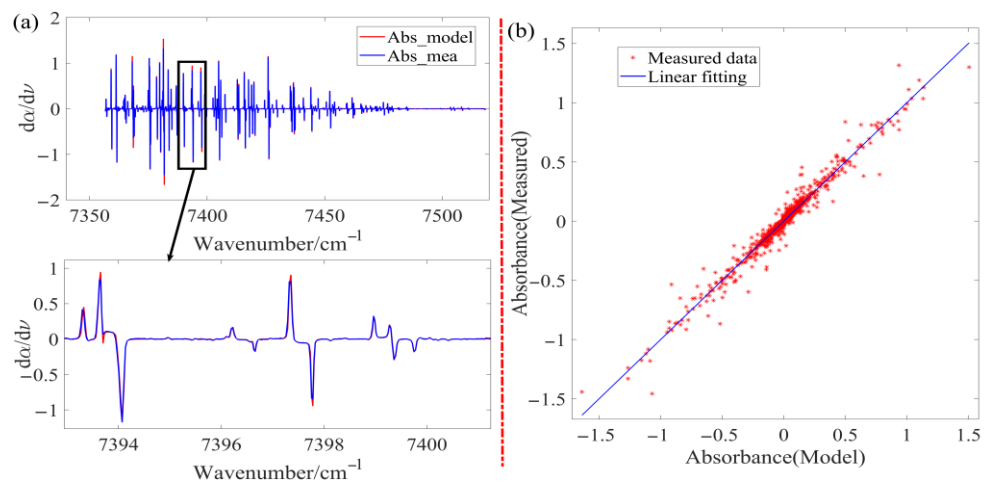


Figure 11. (a) The first derivative of the simulated spectrum and polynomial dual-cosine wavelength-calibrated spectrum (@800 K). (b) Spectral fitting between *Abs_measured* and *Abs_model*.

Figure 11 illustrates the spectral fitting results following the segmented wavelength calibration of the absorption spectrum. It can be observed that *Abs_model* shows excellent agreement with the measured spectrum calibrated via the polynomial double-cosine method, yielding a retrieved temperature of 806.37 K. To further evaluate the performance of the proposed calibration approach, absorption signals measured across the temperature range of 700–1600 K were processed using both the polynomial double-cosine model and a conventional polynomial method. Both datasets were subsequently analyzed through a broadband H_2O absorption thermometry model to retrieve temperatures. The results are presented in Figure 12.

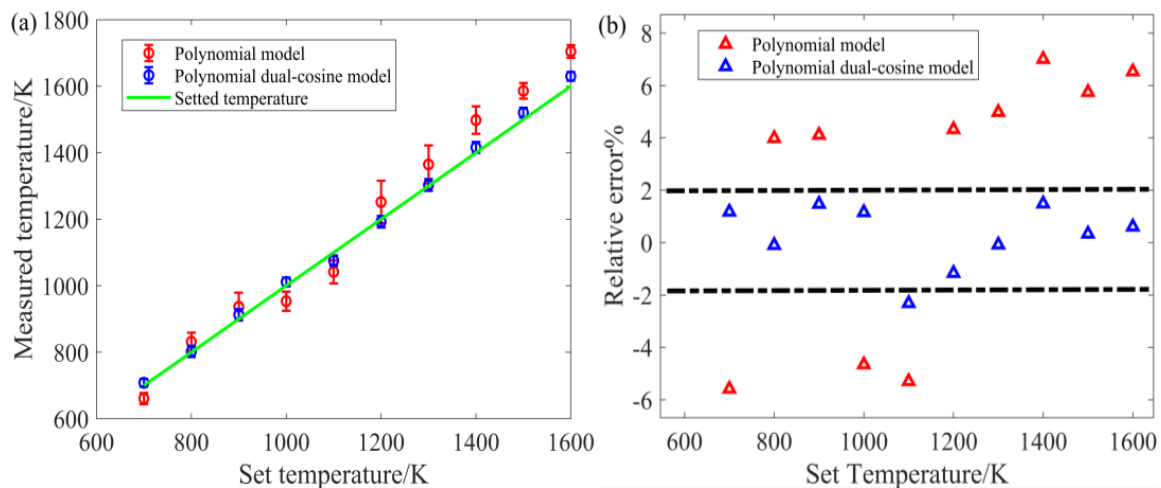


Figure 12. Temperature retrieval results across 700~1600 K. (a) Comparison of temperature error bars using two wavelength calibration models. (b) Comparison of temperature relative errors using two wavelength calibration models.

The polynomial model is a commonly used method for wavelength calibration. It can serve as a reference to evaluate the performance of broadband temperature measurement when using the polynomial dual-cosine model to calibrate wavelength. As shown in Figure 12a, the measured temperatures are closer to the set temperatures when using the polynomial dual-cosine model to calibrate wavelength, and the corresponding temperature error bars are also shorter. In addition, the maximum relative error depicted in Figure 12b is reduced from 6.7% to 2.3%. The reduced error and improved agreement with set temperatures suggest that the proposed polynomial dual-cosine model effectively compensates for both gradual and periodic nonlinearities in wavelength scanning, which are often inadequately addressed by conventional polynomial calibration. And the polynomial dual-cosine model provides an effective solution for wavelength drift issues in broadly tunable light sources with similar characteristics. Moreover, this approach is particularly beneficial in combustion diagnostics where precise measurement is critical. In future, the model parameters will be further optimized to extend the applicable scanning range of this method.

5. Conclusions

The ECDL (Santec-TSL710-O-band) used for broadband temperature measurement suffers from wavelength drift. In this paper, a polynomial dual-cosine model is proposed for the ECDL's wavelength calibration. An analysis of the ECDL's measured spectral data was conducted to evaluate the calibration performance of the polynomial dual-cosine model across different scanning ranges. The results show that the model reduces the relative wavenumber fitting residuals by a factor of five within the 30 cm^{-1} scanning range, and future work will focus on optimizing the PDC model to extend this scanning range limit.

High-temperature tube furnace experiments (700~1600 K) were carried out to compare broadband temperature measurement accuracy using the traditional polynomial model and the proposed polynomial dual-cosine model. The results indicate that wavelength drift significantly impacts temperature measurement accuracy, and the polynomial dual-cosine model effectively reduces the maximum temperature relative error from 6.7% to 2.3%, demonstrating a substantial improvement in broadband temperature measurement precision. The polynomial dual-cosine model exhibits good performance of the ECDL's wavelength calibration, promoting further research on the broadband absorption spectroscopy

thermometry method, such as spectral line calibration and validation of the broadband absorption spectroscopy thermometry method in high-pressure combustion environments.

Author Contributions: Conceptualization, S.A. and Z.X.; methodology, S.A.; software, S.A.; validation, Z.X., A.H. and R.K.; formal analysis, S.A.; investigation, D.S., C.C. and R.N.; resources, W.X., C.D. and Z.Y.; data curation, S.A.; writing—original draft preparation, S.A.; writing—review and editing, Z.X. and A.H.; visualization, Z.X.; supervision, Z.X.; project administration, Z.X.; funding acquisition, Z.X. All authors have read and agreed to the published version of the manuscript.

Funding: The authors declare that financial support was received for the research, authorship, and/or publication of this article. This research was funded by the National Key R&D Program of China (No. 2023YFF0716400), Youth Innovation Promotion Association of Chinese Academy of Sciences (No. 2022451), and Stable Support for Institutes-Research (0200850008).

Data Availability Statement: The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

TDLAS	tunable diode laser absorption spectroscopy
ECDL	external cavity diode laser
PDC	polynomial dual-cosine model

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