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Content of Abstracts

Formation of Analogue Black Holes as Wave-Absorbing Systems via Vortex Flows

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Abstract

The study of analogue black hole structures reveals that wave propagation in their presence is subject to significant constraints. Vortex flows within a fluid generate analogues of rotating black holes by forming an acoustic event horizon that prevents further wave propagation. In this research, we analyze wave dynamics in a fluid with vortex flow and observe that the ultimate fate of the waves depends on multiple factors, including the angle of incidence and the black hole's rotation rate. Generally, waves are either absorbed or scattered by the black hole's rotational forces. The black hole's rotation imparts angular momentum to the waves, even if they initially possess none. Our results demonstrate that counter-rotating waves have a higher probability of absorption compared to co-rotating waves, whereas co-rotating waves are more likely to be scattered than counter-rotating ones. By calculating the critical impact parameter, we quantify the extent of wave absorption or scattering based on the initial conditions of the incoming wave and the system's characteristics.

Keywords: Analogue Black Hole, Acoustic Event Horizon, Vortex Flow, Wave Absorption.

How to site this paper: Shafiee M, Bigdeli H, Asgharzadeh-Bonab A. Formation of analogue black holes as absorbing systems of waves through vortex flows. Hydrophysics. 2024; 10(1):1-14.

Investigation of the Piezoelectric Properties of Mn-Doped PIN-PMN-PT Single Crystal and Its Application in Electro-Acoustic Transducer Fabrication

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Abstract

In this study, a 2 mol% Mn-doped 0.24PIN-0.46PMN-0.3PT relaxor ferroelectric single crystal was grown using the vertical gradient freeze (VGF) method. Its dielectric, piezoelectric, and ferroelectric properties were characterized along the crystallographic direction. At room temperature, the single crystal exhibited a dielectric constant (ε_r) of 3085, an electromechanical coupling coefficient (k_33) of 0.9, and a piezoelectric charge coefficient (d_33) of 1450 pC/N. Comparative analysis of the transmitting response and receiving sensitivity of transducers fabricated from this single crystal versus those made from polycrystalline PZT-5 and PZT-4 ceramics revealed that the maximum transmitting response of Mn:PIN-PMN-PT single crystal elements is approximately 7.5 dB higher than that of PZT-5 and comparable to PZT-4. The transmitting bandwidth of the single crystal transducer is 17 kHz, which lies between the bandwidths of PZT-4 (5 kHz) and PZT-5 (20 kHz). Additionally, the receiving sensitivity of the Mn:PIN-PMN-PT single crystal elements is up to 5 dB higher than PZT-5 and 10 dB higher than PZT-4, although their receiving bandwidth is narrower compared to PZT-4 (2 kHz) and PZT-5 (4 kHz). These results highlight the high potential of Mn:PIN-PMN-PT single crystals for use as both transmitters and receivers in acoustic transducers. The combination of outstanding piezoelectric properties, high coercive field, and excellent thermal stability suggests that Mn-doped PIN-PMN-PT single crystals are promising candidates for high-power transducer applications.

Keywords: Relaxor ferroelectric, Single crystal, Electromechanical coupling coefficient, Piezoelectric charge coefficient, Coercive field, Transducer

How to site this paper: Azizi Y, Yazdanmehr M, Kazerani Vahdani MR, Ahmadvand H. Investigation of the piezoelectric properties of Mn-doped PIN-PMN-PT single crystal and use in the manufacture of electro-acoustic transducer. Hydrophysics.2024; 10(1):15-24.

Investigation of Dissolved Oxygen Levels in the Karun River Water Using Hybrid Models Based on Support Vector Regression

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Abstract

Oxygen plays a vital role in maintaining the balance of life cycles in all ecosystems. Aquatic life is highly sensitive to dissolved oxygen (DO) levels. This necessitates not only continuous monitoring of DO in aquatic environments but also the development of accurate predictive models for future DO concentrations. The aim of this study is to develop a precise prediction model for DO concentration in river water. To this end, a novel hybrid intelligent model based on the support vector regression (SVR) approach was developed to predict dissolved oxygen levels. Three optimization algorithms—Firefly, Gray Wolf, and Bat—were employed to enhance the modeling of DO in river water. The study utilized hydrometric data from the Molasani station on the Karun River in Khuzestan Province as a case study, covering five combined input parameter scenarios over the period 2012–2022. Model performance was evaluated using correlation coefficient (R), root mean square error (RMSE), mean absolute error (MAE), and Nash–Sutcliffe efficiency coefficient (NSE). Results demonstrated that combined input scenarios improved model performance across all models. Among them, the SVR-Firefly hybrid model achieved the best validation results with a correlation coefficient of 0.970, RMSE of 0.668 mg/L, MAE of 0.520 mg/L, and NSE of 0.975. Overall, the findings indicate that intelligent models based on the support vector regression approach provide an effective tool for sustainable river engineering management.

Keywords: Dissolved Oxygen, Support Vector Regression, Karun, Modeling

How to site this paper: Babaali H, Nohani E, Dehghani R. Investigating the amount of Dissolved Oxygen in the Water of the Karun River with Hybrid Models based on Support Vector Regression. Hydrophysics.2024; 10(1): 25-34.

The Effect of Pacific Ocean Teleconnection Patterns on Relative Humidity along the Southern Coasts of Iran

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Abstract

This study examines the relationship between relative humidity at stations located in the plains and along the southern coasts of Iran and Pacific Ocean teleconnection patterns. Using statistical methods—including Pearson correlation analysis, analysis of variance, and backward regression—data from 25 synoptic stations and 14 Pacific Ocean teleconnection indices were analyzed. The results revealed that, at the regional scale, the strongest correlations between Pacific Ocean patterns and relative humidity along Iran's southern coasts were observed with the SOI pattern (-0.75), followed by the TROPICAL SST, PDO, and PWARMPOOL patterns (0.7). These patterns explained relative humidity variations at Kangan-e-Jam (91%) and Bandar Mahshahr (90%) stations with high accuracy. Additionally, multiple correlation coefficients and coefficients of determination were calculated for Minab (84%), Bandar Jask (80%), Omidiyeh (77%), Bandar Lengeh (74%), Bushehr (73%), Abadan (66%), Bandar Abbas (61%), and Chabahar (46%). These variations reflect differing regional sensitivities to climatic patterns, likely influenced by local geographical and climatic factors. Multivariate regression models indicated the strongest relationships between relative humidity and the SOI, NINO3.4, ENSO, and TNI indices, followed by the PWPOOL and WHWP patterns. The findings demonstrate that Pacific Ocean teleconnection patterns effectively explain relative humidity variability. Moreover, the complexity of the regional climate system and the simultaneous influence of multiple teleconnection patterns highlight the need for comprehensive multivariate models in regional climate change analyses. This study underscores the importance of teleconnection pattern analysis in understanding regional climate variability and suggests their potential as valuable tools for climate risk prediction and management.

Keywords: Climate Patterns, Pasific Ocean, southern coasts of Iran, Correlation, Teleconnection

How to site this paper: Esmaeilzadeh Z, Salahi B, Saber M. The Effect of Pacific Ocean Teleconnection Patterns on the Relative Humidity of the Southern Coasts of Iran. Hydrophysics. 2024;10(1):35-52.

Improving Regional Bathymetry Estimation Using Data Integration and Assimilation of Geodetic Observations (Case Study: Persian Gulf and Sea of Oman)

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Abstract

Accurate bathymetry modeling is crucial for various marine applications, including navigation, resource exploration, and environmental studies. This study presents an innovative approach to enhance bathymetric modeling in the Persian Gulf and Sea of Oman by integrating data assimilation techniques with geodetic observations. The method combines satellite altimetry missions, the XGM2019e gravity model, and ship-borne marine gravity data to derive gravity anomalies. Using the Variance Component Estimation (VCE) method for weighting and residual analysis, these three data sources are fused to produce a final gravity anomaly estimate. Comparison of ship-borne gravity anomaly control profiles with satellite altimetry, XGM2019e, and the integrated gravity anomaly demonstrates the superior accuracy of the integrated product over individual data sources. Subsequently, the integrated gravity anomaly is applied within the Parker physical model to estimate seabed depth. To refine the estimated bathymetry and achieve local calibration, three-dimensional variational data assimilation (3DVAR) is employed, incorporating echosounder observations to improve depth estimates in the physical model. Finally, the assimilated bathymetry is validated against control points obtained from echosounder measurements. Results indicate that data assimilation significantly enhances the accuracy of bathymetric estimates derived from the physical model.

keywords: Bathymetry, Data Assimilation, Satellite Altimetry, Parker Model, Variance Component Estimation (VCE)

How to site this paper: Mohammad MA, Jazireeyan I, Pirooznia, M. Improving regional bathymetry modeling using data fusion and assimilation of geodetic observations (case study: Persian Gulf and Oman Sea). Hydrophysics. 2024; 10(1):53-66.

Motion Control of an Unmanned Sailing Boat Subject to Surface Disturbances Based on an Integrated Optimal Feedback Linearization Algorithm

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Abstract

This article presents the design of heading and speed controllers for an unmanned sailing boat that effectively utilizes natural wind power to navigate maritime paths. Considering the nonlinear dynamics governing the sailboat and the disturbances caused by water currents, two separate controllers are employed to manage the heading and speed under these perturbations. The proposed method uses an input-output feedback linearization controller to track the desired heading angle, while an innovative optimal controller regulates the sail angle to maximize speed. In the feedback linearization approach, nonlinear terms are canceled to linearize the system, enabling the design of a heading controller that ensures the output accurately follows the desired input. The sail angle controller is designed to achieve maximum speed based on the actual wind direction and speed. Simulation results, compared with a conventional PID control method, show that the optimal feedback linearization controller tracks the reference heading faster—by approximately 20 seconds in some cases—and achieves an average speed increase of about 20% over the PID controller.

Keywords: Unmanned sailboat, Sail angle, Rudder angle, Feedback linearization

How to site this paper: Jalili MR, Vali A, Alirezapouri M, Normohammadi H. Motion control of an unmanned sailing boat subject to surface disturbances based on integrated optimal feedback linearization algorithm. Hydrophysics. 2024; 10(1): 67-82.

Two-Dimensional Numerical Modeling of Flow in the Physical Model Scale of the Karun River (Upstream of the Jangieh Meander)

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Abstract

Recent advances in computational power and numerical methods have greatly improved the accuracy of modeling water flow and sediment transport processes. This study explores the application of the two-dimensional numerical HEC-RAS model to predict hydraulic parameters in a river meander, validated against a physical model of the Karun River at the Jangieh meander. The modeled reach extends 40 km from Ahvaz to Farsiat and includes measurements of water surface elevation and flow velocity. Results demonstrate that the numerical model accurately reproduces flow velocity patterns similar to those observed in the physical model, with performance metrics of $R^2 = 0.941$, RMSE = 0.04 m/s, and Nash–Sutcliffe Efficiency (NSE) = 0.88. Mesh characteristics significantly influenced velocity distribution accuracy, with high-resolution regular grids providing the best simulation results. Appropriate simulation duration and time step selection were critical, with a typical time step of 0.5 seconds used in most simulations. Additionally, analysis of satellite imagery spanning the last 51 years indicates that the riverbanks in the Jangieh meander region are prone to erosion due to elevated shear stress. These findings underscore the importance of integrated hydraulic and sediment monitoring for sustainable management of meandering rivers.

Keywords: Numerical Modeling, Physical Model, Meander, Karun River, Satellite Imagery.

How to site this paper: sadigh A, ghomeshi M, zayeri M. Two-Dimensional Numerical Modeling of Flow in Physical Models of the Karun River (Upstream Of the Jangieh Meander). Hydrophysics. 2024;10(1):83-98.

Crack Detection in a Rectangular Plate of Surface Effect Floats Using the Singular Spectrum Algorithm (SSA)

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Abstract

This article investigates the detection of a crack measuring five centimeters in length and one millimeter in depth in a rectangular aluminum 6061 plate with a thickness of one millimeter, used in surface effect floats. Initially, the rectangular plate and crack were modeled and subjected to impact simulation using Abaqus software. Subsequently, strain data from various points on the structure were extracted from Abaqus, contaminated with noise, and then decomposed into their intrinsic modes using the Singular Spectrum Algorithm (SSA). The standard deviation of each mode was calculated to facilitate fault detection. The results demonstrate the high capability of this method to simultaneously identify multiple defects, particularly in the shell structure of surface effect floats.

Keywords: Singular Spectrum Algorithm, Crack Detection, Impact Loading, Surface Effect Float Hull Structure

How to site this paper: Shirzadifar M, Abdolahifar A. Crack detection in a Rectangular Plate of Water Surface Effect Floats Based on Singular Spectrum Algorithm (SSA). Hydrophysics.2024;10(1):99-112.

Control of Scour in Front of Piers Using a Curved Deflecting Nose

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Abstract

Local scour around pier foundations is the primary cause of pier damage. Numerous studies have addressed this phenomenon, proposing various protection methods that can be broadly classified into direct and indirect approaches. One effective indirect method to reduce scour depth is by modifying the flow patterns around the pier through altering the nose shape of the pier. This experimental study investigates the effect of changing the pier nose shape aligned with the flow direction. Curved-nose piers with arc radii of 52.28 cm, 20.20 cm, 12.09 cm, and 11.06 cm were tested under clear-water conditions. Results show that the pier with the smallest radius (11.06 cm) exhibited the best performance, achieving optimal scour reduction at relative flow velocities up to 95% of the particle incipient motion threshold velocity.

Keywords: Scour, Pier, Curved Nose Radius, Incipient Motion

How to site this paper: Bakhtiari M, Solimani Babarsad M, Safaei A. Control of Scour in Front of Piers Using a Curved Deflecting Nose. Hydrophysics.2024; 10(1):113-25.

Reinforcement of Underwater Steel Pipes Against Blast Loads Using GFRP

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Abstract

Analyzing the behavior of underwater steel pipes under explosive loading is critical due to their essential role in marine infrastructure. This study investigates the effects of underwater explosions with three different TNT masses located 5 meters from the pipe using numerical simulations in ABAQUS. The results demonstrate that increasing TNT mass leads to higher kinetic energy and strain in the pipe. Furthermore, the effectiveness of four different reinforcement configurations using GFRP sheets was evaluated. Continuous GFRP wrapping proved to be the most effective, reducing the maximum local deformation of the pipe by over 52%. Although discrete GFRP rings offered partial protection, local stresses at the ring-pipe interfaces limited their overall effectiveness. Findings also indicate that underwater explosions inflict less damage on pipes compared to air explosions, owing to greater energy dissipation in the water environment. This research provides practical strategies to enhance pipeline resistance against explosive loads and can inform the design and reinforcement of underwater pipes.

Keywords: Steel pipes, Underwater explosions, GFRP, UNDEX

How to site this paper: Esmailzadeh M, Behdarvandi Askar M. Reinforcement of underwater steel pipes against blast load using GFRP. Hydrophysics. 2024; 10(1):127-39.

Experimental Study of a Seaplane Hull Model in Porpoising Mode

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Abstract

The occurrence of longitudinal oscillations during hydrodynamic tests of seaplane models in towing tanks has motivated this research. This study experimentally investigates porpoising behavior in the hull model of a seaplane. Due to the inherent risks of porpoising, initial efforts ensured that the phenomenon was both observable and repeatable throughout various test stages. The effects of modifying operational parameters—including shifting the center of gravity, increasing speed within the porpoising regime, reducing weight, applying an initial longitudinal moment, as well as the presence, absence, and displacement of skis—were systematically examined. Weight and center of gravity reductions correspond to fuel consumption or payload unloading in practical operation. All tests were repeated to verify result accuracy. Findings indicate that adjusting certain parameters can extend the stability range of the hull by increasing the speed at which porpoising initiates.

Keywords: Porpoising, Planing Hull, Hydrodynamic Stability, Sliding Fuselage, towing tank

How to site this paper: Norouzian M, Saranjam B. Experimental Study of a Seaplane Hull Model in Porpoising Mode. Hydrophysics. 2024; 10(1):141 -48.

Study of the Energy Redistribution Process in a Zero-Pressure-Gradient Flat-Plate Turbulent Boundary Layer Using Large-Eddy Simulation

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Abstract

This study investigates the process of energy redistribution within a turbulent boundary layer over a flat plate without a pressure gradient at various Reynolds numbers, utilizing large eddy simulation (LES) results. The three-dimensional, time-dependent filtered Navier–Stokes equations for incompressible Newtonian fluid flow were numerically solved. Subgrid-scale stresses were modeled using the wall-adapting local eddy-viscosity (WALE) model. An oscillatory inflow boundary condition was applied to generate physical turbulence at the inlet, which shortened the required computational domain length and reduced computational cost. Turbulent statistical quantities obtained from the simulations were validated against existing experimental data and direct numerical simulation (DNS) results, confirming high accuracy. These data were subsequently used to analyze the turbulent kinetic energy redistribution process within the boundary layer, providing insight into the behavior of Reynolds normal stresses. Additionally, comparison with DNS results assessed LES accuracy in capturing the energy redistribution process. It was observed that LES underestimates the absolute maximum and minimum values of the principal components of the pressure–strain correlation tensor relative to DNS.

Keywords: Large-eddy simulation, Turbulent boundary layer, WALE subgrid-scale model, Oscillatory inflow condition, Energy redistribution process

How to site this paper: Moosaie A. Study of the Energy Redistribution Process in a Zero-Pressure-Gradient Flat-Plate Turbulent Boundary Layer Using Large-Eddy Simulation. Hydrophysics. 2024; 10(1):149-65.