Contributed Session 01: Equations and Qualitative Analysis

Stability of equilibria for the $\mathfrak{so}(4)$ free rigid body

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The stability for all generic equilibria of the Lie-Poisson dynamics of the $\mathfrak{so}(4)$ rigid body dynamics is completely determined. It is shown that for the generalized rigid body certain Cartan subalgebras (called of coordinate type) of $\mathfrak{so}(n)$ are equilibrium points for the rigid body dynamics. In the case of $\mathfrak{so}(4)$ there are three coordinate type Cartan subalgebras whose intersection with a regular adjoint orbit give three Weyl group orbits of equilibria. These coordinate type Cartan subalgebras are the analogues of the three axes of equilibria for the classical rigid body in $\mathfrak{so}(3)$. In addition to these coordinate type Cartan equilibria there are others that come in curves. For each case of nonlinear stability previously found, for the $\mathfrak{so}(4)$ free rigid body, we construct a Lyapunov function. These Lyapunov functions are linear combinations of Mishchenko's constants of motion.

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Triple collision dynamics in chaotic photoionization of planar helium

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Recently photoionization cross sections were accurately calculated for the 1-dimensional collinear helium model, which show chaotic fluctuations as a function of the total energy. Based on the underlying classical mechanics of the two-electron atom, we found that the fluctuations can be characterized by the closed triple collision orbits starting and ending at the triple collision. Extension of our theory to the planar helium atom is straightforward without any serious modification. However, quantum calculations of the photoionization cross sections of planar helium is a challenge, especially for higher energies close to the double ionization threshold where the classical - quantum correspondence holds. We present accurate results of the quantum calcaulation for planar helium and interprete them in terms of quantities associated with the classical mechanics of two-electron atoms.

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Existence and uniqueness of solution to an integral boundary value problem for impulsive fractional functional differential equations with infinite delay

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In this work, we prove the existence and uniqueness of solutions to an impulsive fractional functional integro-differential equations with an integral boundary condition. We prove our result by applying some well known fixed point theorems.

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Decay and destruction of invariant Tori in volume preserving maps

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Invariant tori play a prominent role in the dynamics of symplectic maps. These tori are especially important in two dimensional systems where they form a boundary to transport. Volume preserving maps also admit families of invariant rotational tori, which will restrict transport in a d dimensional map with one action and $d-1$ angles. These maps most commonly arise in the study of incompressible fluid flows, however can also be used to model magnetic field-line flows, granular mixing, and the perturbed motion of comets in near-parabolic orbits. Although a wealth of theory has been developed describing tori in symplectic maps, little of this theory extends to the volume preserving case. In this talk we will explore the invariant tori of a 3 dimensional quadratic, volume preserving map with one action and two angles. A method will be presented for determining when an invariant torus with a given frequency is destroyed under perturbation, based on the stability of approximating periodic orbits.

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Stability of fixed points for periodic Hamiltonian systems

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In this talk we study the stability of equilibria for periodic Hamiltonian systems with one and a half degrees of freedom. We focus on systems coming from the second Newton's Law and we show that equilibria are unstable solutions when the force depends on time periodically and at the equilibria is increasing. We give conditions to determine when the equilibria have hyperbolic structure. We show some examples exhibiting the powerful of the above result.

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Global asymptotic behavior of some nonlinear nonautonomous difference equations

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We study the global asymptotic behavior of some classes of nonlinear nonutonomous difference equations with and without delay. The main emphasis was placed on special class of periodic difference equations. In particular, the questions of boundedness, existence of unbounded solutions, oscillations, and extreme stability are addressed. For periodic systems we also study the existence and stability of periodic solutions, attenuance and resonance of periodic cycles. Examples include some well-known nonautonomous population models.

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Existence and uniqueness of bounded solution for nonlinear functional differential equation with anticipation and retardation

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We discuss the existence of unique bounded solution for nonlinear first order functional differential equations with anticipation and retardation (FDEAR)

$$u'(t) = f(t, u(t-h_1), u(t), u(t+h_2)), \quad t \geq t_0,$$

$$u(t) = a(t), \quad t \in [t_0 - h_1, t_0]$$

where $h_1 > 0$ and $h_2 > 0$ employing the iterative technique.

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Almost periodicity in hereditary systems of second order

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In this work we study the existence of asymptotically almost periodic solutions for a class of second order abstract neutral differential equations with unbounded delay described in the form

$$\frac{d^2}{dt^2}[x(t) + g(t, x_t)] = Ax(t) + f(t, x_t), \quad t \in [0, \infty)\,(1)$$

$$x_0 = \varphi \in \mathcal{B}, \qquad (2)$$

$$x'(0) = \xi \in X, \qquad (3)$$

where A is the infinitesimal generator of a strongly continuous cosine family of bounded linear operators on a Banach space $(X, \|\cdot\|)$, the history $x_t : (-\infty, 0] \to X$, $x_t(\theta) = x(t+\theta)$, belongs to an abstract phase space $\mathcal{B}$ defined axiomatically and f, g are suitable functions.

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An analytical approach to the stability of horizontally sheared flow

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We investigate the stability of a shear flow in a stratified fluid. The flow is assumed to be inviscid and Boussinesq and the base state density gradient is vertical with constant Brunt-Vaisala frequency. The shear is taken as horizontal, where the base-state velocity has uniform direction and it's magnitude depends on the transverse horizontal coordinate, U(y). Unlike vertical shear flows, this combination of horizontal shear with vertical stratification is inherently three-dimensional and Squire's theorem is inapplicable. Analytical normal-mode solutions are obtained for an entire class of velocity profiles using the Riccati transform. For other velocity profiles the results are determined by numerical methods. Sensitivity of the stability characteristics and their qualitative features are investigated for free-shear flows, such as the hyperbolic tangent velocity profile, and jet-like flows, such as a Gaussian profile.

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On the stability of solutions of a class of neutral differential equations with multiple deviating arguments

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In this paper, using the Lyapunov-Krasovskiĭ functional approach, some novel stability criteria are given for all solutions of a class of nonlinear neutral differential equations to tend zero.

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