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%% Imaging System Analysis Modeling
% Project: Detector Modeling
% Author: Jared Gregor (jmg2586@rit.edu)
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%% Task 1
clear

% Given Variables
L = 1024; % Saturation level
eta = [1.0, 0.5, 0.25, 0.125];
q = [1:200:8001]; % Lambda/ Mean exposure
q_scaled = [q;q;q;q]; % Scale q for each eta
q_scaled = q_scaled ./ eta';


noise_read = 0; % Electrons
noise_AD = 0;

% Calculate dqe with 0 noise
dqe(1,:) = DQE(L, q, eta(1), noise_AD, noise_read);
dqe(2,:) = DQE(L, q, eta(2), noise_AD, noise_read);
dqe(3,:) = DQE(L, q, eta(3), noise_AD, noise_read);
dqe(4,:) = DQE(L, q, eta(4), noise_AD, noise_read);

% Plot DQE vs q
Plot1(q_scaled, dqe)

% Add noise
noise_read = 10; % Electrons
AD = 4; % bits
noise_AD = NoiseAD(L, AD);

% Calculate dqe with constant read and AD noise
dqe(1,:) = DQE(L, q, eta(1), noise_AD, noise_read);
dqe(2,:) = DQE(L, q, eta(2), noise_AD, noise_read);
dqe(3,:) = DQE(L, q, eta(3), noise_AD, noise_read);
dqe(4,:) = DQE(L, q, eta(4), noise_AD, noise_read);

% Plot DQE vs q with noise
Plot1(q_scaled, dqe)

%% Task 2
clear

% Given Variables
L = 1024; % Saturation level
eta = 0.5;
q = [1:200:3001]; % Lambda/ Mean exposure
q_scaled = q ./ eta;
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% DQE varying read noise
noise_read = [1,3,10];
noise_AD = 0;

% Calculate DQE varying read noise and 0 AD noise
dqe(1,:) = DQE(L, q, eta, noise_AD, noise_read(1));
dqe(2,:) = DQE(L, q, eta, noise_AD, noise_read(2));
dqe(3,:) = DQE(L, q, eta, noise_AD, noise_read(3));

Plot2(q_scaled, dqe,["read noise = 1", "read noise = 3", "read noise = 10"])

% DQE varying bit level
noise_read = 0;
AD = [2,4,8];
noise_AD = NoiseAD(L, AD);

% Calculate DQE varying AD noise and 0 read noise
dqe(1,:) = DQE(L, q, eta, noise_AD(1), noise_read);
dqe(2,:) = DQE(L, q, eta, noise_AD(2), noise_read);
dqe(3,:) = DQE(L, q, eta, noise_AD(3), noise_read);

Plot2(q_scaled, dqe,["AD noise = 2", "AD noise = 4", "AD noise = 8"])

%% Task 3
noise_read = 0;
noise_AD = 0;

diameter = [5,10,20]; %Square Pixel diameter microns
multiplier = [16, 4, 2]

E = multiplier .* q;
logE = log(E);

%% Task 4
clear

%% Task 5
clear

%% Functions

% AD noise
function noise = NoiseAD(L, AD)
    noise = (L.^2)./(12.*2.^(2.*AD));
end

% DQE
function dqe = DQE(L, q, eta, noise_AD, noise_read)

    % Compute f1 (eq 6)
    f1 = 0;
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    for i = 0:L-1
        f1 = f1 + (1/L) * poisscdf(i,q);
    end

    % Compute f2 (eq 9)
    f2 = (1/L) * poisscdf(L-1,q);

    % Compute f3 (eq 16)
    f3 = 0;
    for i = 0:L-1
        f3 = f3 + ((1/(L*L)) * (2*i+1) * poisscdf(i,q));
    end


    % Calculate DQE(qN) (Eq 21)
    DQE_qN = (q.*f2.*f2.*L.^2)./(noise_AD + noise_read^2 + L.^2 *((1.-f3)-(1.-f1).^2));

    % Calculate DQE(q) (Eq 24)
    dqe = DQE_qN .* eta;
end

function Plot1(q_scaled, dqe)
    figure
    hold on
    plot(q_scaled(1,:), dqe(1,:), '-')
    plot(q_scaled(2,:), dqe(2,:), '--')
    plot(q_scaled(3,:), dqe(3,:), '-.')
    plot(q_scaled(4,:), dqe(4,:), ':')
    xlim([0 10000])
    ylim([0 1.2])
    legend('eta = 1', 'eta = 0.5','eta = 0.25','eta = 0.125')
    title('DQE vs Mean # q')
    ylabel('DQE')
    xlabel('q, photons')
    hold off
end

function Plot2(q_scaled, dqe, leg)
    figure
    hold on
    plot(q_scaled, dqe(1,:), '-')
    plot(q_scaled, dqe(2,:), '--')
    plot(q_scaled, dqe(3,:), ':')
    xlim([0 3000])
    ylim([0 0.6])
    legend(leg(1), leg(2), leg(3))
    title('DQE vs Mean # q')
    ylabel('DQE')
    xlabel('q, photons')
    hold off
end
```

```
function Plot3(q_scaled, dqe, leg)
    figure
    hold on
    plot(q_scaled, dqe(1,:), '-')
    plot(q_scaled, dqe(2,:), '--')
    plot(q_scaled, dqe(3,:), ':')
    xlim([0 3000])
    ylim([0 0.6])
    legend(leg(1), leg(2), leg(3))
    title('DQE vs Mean # q')
    ylabel('DQE')
    xlabel('q, photons')
    hold off
end

function Plot4(q_scaled, variance, leg)
    figure
    hold on
    plot(q_scaled, variance(1,:), '-')
    plot(q_scaled, variance(2,:), '--')
    plot(q_scaled, variance(3,:), ':')
    xlim([0 3000])
    ylim([0 0.6])
    legend(leg(1), leg(2), leg(3))
    title('Variance vs normalized mean count level')
    ylabel('DQE')
    xlabel('q, photons')
    hold off
end

function Plot5(q_scaled, dqe, leg)
    figure
    hold on
    plot(q_scaled, dqe(1,:), '-')
    plot(q_scaled, dqe(2,:), '--')
    plot(q_scaled, dqe(3,:), ':')
    xlim([0 3000])
    ylim([0 0.6])
    legend(leg(1), leg(2), leg(3))
    title('DQE vs log(mean # photons / 400 microns^2)')
    ylabel('DQE')
    xlabel('log E, photons/400 micron^2')
    hold off
end
```